EXPERIENCE AND VIEWPOINTS IN THE SOCIAL DOMAIN OF SPACE TECHNOLOGY

by

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Experience and Viewpoints in the Social Domain of Space Technology

Abstract

This thesis is about how space technology is experienced in the social domain and how its purpose is recast from different viewpoints. The author is an artist and the approach taken foregrounds qualities of experience and viewpoint in which artists have a particular investment. This approach opens up the ways that affect, agency and authorship cross social domains that are directly and indirectly associated with the production of space technologies. A key focus is a group project led by the author that was initiated in response to the launch in October 2008 of the Chandrayaan-1 spacecraft by the Indian Space Research Organisation (ISRO). The project took place in Bengaluru, India where the spacecraft was built.

Taking the ambivalence that surrounds the uses and purposes of space technologies as a starting point, a description of the spacecraft is developed from a number of viewpoints, including the mission scientists, public media and the participants of the artist-led project. The interventionist strategies of the project shed light on the ways that technologies can be accessed through their imaginaries and this has significance for large-scale technologies, such as spacecraft, for which physical access is delimited and much of the infrastructure is invisible or hidden from public view.

The thesis proposes ways of reinstating missed qualities of viewpoint and experience within the affective spaces of space technology through the imperative to articulate first-person engagements with the world that is bound into artistic interpretation. What is further proposed is that by picturing the interrelations and flows of space technology in social domains through the lenses of experience and viewpoint, a 'technographic picture' is created that then becomes available as a tool with which to re-imagine spacefaring. This is a crucial addition to discussions about the interplay between science, technology and society that recognises the intimate spaces at the core of such large-scale concepts. It offers a new transdisciplinary modality that incorporates an artistic approach with which to make sense of the structurally ambivalent pursuits of spacefaring.

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List of abbreviations and ISRO Chairs

BGVS – Bharat Gyan Vigyan Samiti (A People's Science Movement translating as Indian Organisation for Learning and Science)

BJP – Bharatiya Janata Party (political party)

DOS – Department of Space (Indian government)

ESA – European Space Agency

GSLV – Geostationary Satellite Launch Vehicle

IGY – International Geophysical Year

INSAT – Indian National Satellites

IRS – Indian Remote Sensing

ISRO – Indian Space Research Organisation

KSSP - Kerala Sasthra Sahithya Parishad (A People's Science Movement in Kerala translating as The Kerala Forum for Science Literature)

NASA - National Aeronautics and Space Administration

PSLV – Polar Satellite Launch Vehicle

SITE – Satellite Instructional Television Experiment

SLV – Satellite Launch Vehicle

ISRO Chairs:

Vikram Sarabhai (1963-1971)
M.K.K. Menon (1972)
Satish Dhawan (1972-1984)
U.R. Rao (1984-1994)
K. Kasturirangan (1994-2003
Madhavan Nair (2003-2009)
K. Radhakrishnan (current Chair in 2014)

Acknowledgments

I have many, many to thank for their contribution to the formation of this thesis

First I wish to acknowledge the Moon Vehicle teams of students from Srishti School of Art, Design and Technology in Bengaluru whose questions, insights and hard work were the generator for the project. Moon Vehicle was made possible through the creative vision of Geetha Narayanan, Founder/Director of Srishti School of Art, Design and Technology and with funding from the Sir Ratan Tata Trust. The supportive space of the Centre for Experimental Media Arts (CEMA) at Srishti, developed by Meena Vari, Gabriel Harp, Yashas Shetty and Zack Denfield, allowed the project to emerge over time in correspondence with other inspirational artist's projects. It is very rare that an artist is given financial and institutional support for more than three or six months to develop a project. Srishti provided the conditions for a sustained long-term inquiry that allowed freedom to explore and experiment. More than this, Geetha Narayanan's implicit trust in the artistic process gave artists-in-residence at Srishti confidence to believe that through the artistic approach profound shifts could take place. I wish to also acknowledge the group of individuals who came up with the idea of the Moon Vehicle project amongst whom were Rob La Frenais, Roger Malina, Geetha Narayanan, Sundar Sarukkai and Nicola Triscott for articulating the necessity for such a timely intervention into the domain of spacefaring.

I wish to thank the following Srishti students for their participation in the Moon Vehicle projects Govind Mohandas, Nandini Chandavarkar, Aajwanthi Baradwaj, Sumona Chakravarty, Kriti Chaudhary, Tejas Pande, Kavya Jha, Bidisha Das, Ritwik Sauntra and faculty Gabriel Harp (for developing the initial Moon Vehicle project for the Microsoft Design Expo in 2008). Special thanks to Alisha Panjwani who worked on several projects and whose energetic and creative input contributed substantially to the project long-term. I also want to acknowledge the work of Babita Belliappa who was with Moon Vehicle from the very beginning. Her drive, social ingenuity, language skills and confidence forged our networks and also made the project great fun.

The most memorable and thought-provoking episodes of Moon Vehicle came about through the work of the children at Drishya Learning Centre where I ran two workshops a year apart.

Thanks to Vidya Prakash for her extraordinary capacity to facilitate the Moon Vehicle summer schools at Drishya Learning Centre that needed many kinds of translation, interpretation and pedagogy. Thanks to the special talents of Anitha Santhanam for developing the creative performances of the children at Drishya from their encounters with space technology. Thanks to the children of Drishya who participated in the two summer schools and made Moon Vehicle legend!

I wish to acknowledge also in the co-production of Moon Vehicle the participation of scientists from ISRO as well as the Indian Institute of Astrophysics especially thanks to P. Sreekumar, Shyama Narendranath, K.R. Sreenath, Prajval Shastri and Sabyasachi Chatterjee. Through their motivation Moon Vehicle expanded as a project into the astronomy festival Kalpaneya Yatre: Journey of Imaginations. During the realisation of the festival I was exposed to, if not immersed in, the many ways that connections and interpretations of cosmos are forged and brokered. I wish to thanks colleagues for their generative insights, which provided a form of primary, research and greatly informed my thinking. Thanks go to many including Deepak Srinivasen, Gauri Sanghi, Rajasee Ray, Nicolas Grande, Alison Byrnes, Kalpana Tanwar, Sabina von Kessel, Rustam Vania, Meena Vari, Geetanjali Sachdev, Ajai Narendran, the Green Chakra group; staff of the Jawaharlal Nehru Planetarium including B.S. Shylaja, C.S. Shukre, Madusudhan; staff of the Visvesvaraya Industrial and Technological Museum especially Sunil Kumar for talking to me about the origins of the Space Gallery exhibit; the wonderful science teacher Gayatri and her pupils of Madivaala Government School. Thanks to Biman Nath at the Raman Research Institute for useful discussions about science and astronomy as well as arranging my visit to Ooty Radio Telescope and to Biswajit Paul for talking to me about the Astrosat mission. Thanks to the Indian Institute of Astrophysics for facilitating my visits to Kodaikanal Observatory and Kavalur Observatory and to my kind hosts at all of these extraordinary astronomy sites.

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There have been many points during the process of the PhD when I have needed to draw on the inspiring influence of past tutors and I would like to acknowledge here the durational influence of my teachers at Edinburgh University, University of Pennsylavania and at Richard Barbrook's idiosyncratic Hypermedia Studies Masters programme at Westminster University. I would like to acknowledge the profound influence of two teachers whose methods made a mark on me and are present within the methods of this thesis. In Robert Hillenbrand's tutorials at Edinburgh University Fine Art Department we use to look at original Islamic manuscripts in the library collection. Professor Hillenbrand taught me that the way to analyse images was to look and describe what you saw. "Look" he would say, "LOOK!" if we students drifted in any way into irrelevant speculation. These tutorials were journeys of discovery and the manuscript images we studied so carefully still resound for me with the sounds of trumpets being blasted from castle walls, the charges of cavalry across double page spreads, the tranquility of water fountains in court gardens and the intrigues of the figures darting through complex architectures. The second teacher I would like to acknowledge is the late Leo Steinberg. At the University of Pennsylvania I was privileged to be included in Leo Steinberg's seminar classes on Picasso. Professor Steinberg again compelled his students to look unflinchingly and he taught that by trusting the intentions of the image and painter the intellect of an image could be accessed. These lessons in looking have stayed with me and they have guided my approach to unraveling the complexities of my thesis puzzle. It is the particular looking that is acquired from the position of an artist that I value most for which I acknowledge the teaching of many tutors and thank in particular Elspeth Lamb, Marcus Rees Roberts, Neil Welliver, Sy Sillman as well as those important art teachers from school years who all taught me how to be an artist.

I thank those voyagers with satellites whose research paths have crossed with mine – Alejo Duque, Lisa Parks, Pedro Soler, the participants of the Orbitando Satélites workshop in Gijon and the participants of the Satellites Exposed workshops in Belfast. Thanks to research buddies Flavia Amadeu, Joanna Hoffmann and Ulrike Mothes, who have given solidarity. I thank my good friends in the United Kingdom, India and elsewhere who bravely ask me what it is that I do and inadvertently clarify my thinking. My special thanks to Jobin Kanjirakkat for giving astute and thoughtful critique and for sharing the conversations of these last stages of writing.

I am lucky to have two wonderful parents who have supported my intellectual journey with genuine interest and an unswerving belief in my ability. This has been a miraculous antidote to the sheer hard work of the PhD and a most welcome comfort. Finally, as a gesture of thanks for the contributions of so many children of exceptional creative virtuosity who participated in Moon Vehicle and other workshops, I would like to dedicate this thesis to my clever and artistic nieces and nephew.

Joanna Griffin

May 2014

AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

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A programme of advanced study was undertaken, based with the Transtechnology Research Group in the School of Arts and Media. Relevant seminars and conferences were regularly attended at which work was presented; external institutions were visited for consultation purposes and several papers prepared for publication. The following is a list of publications, conferences and other public outcomes completed during the Doctoral programme.

Publications:

Griffin, J. (2013) 'Science and Society 2013: Some thoughts on the idea of bias and the idea of ignorance'. [Online] *Situating Science.* 29 October 2013. Available at: http://www.situsci.ca/?q=fr/science-and-society-2013-some-thoughts-idea-bias-and-idea-ignorance (Accessed: 25 April 2014).

Griffin, J. (2013) 'Hitchhiking to the Moon'. *Transtechnology Research Open Access Papers*, [Online]. Available at: http://www.trans-techresearch.net/papers/ (Accessed: 4 October 2013).(forthcoming publication in Moon Manifesto by The Arts Catalyst)

Griffin, J. (2012) 'Moon Vehicle: Reflections from an artist's-led children's workshop on the *Chandrayaan-1* spacecraft's mission to the Moon'. *Leonardo*, 45 (3). pp 219-224.

Griffin, J. (2012) 'Artistic practice as a means for recognising the value of autonomous spacefaring activities', [conference proceedings]*63rd International Astronautical Congress*. Naples. International Astronautical Federation.

Griffin, J. (2012) 'The incorporation of transdisciplinary thinking into the development of hitchhiking payloads'. [conference proceedings] *63rd International Astronautical Congress*. Naples. International Astronautical Federation.

Griffin, J. (2010) 'Finding Meaning', [conference proceedings] *Global Lunar Conference*. Beijing, China.

Presentations:

2013 *Language, Art and Authorship: A comparative approach towards making sense of the science-society question* (with Jobin Kanjirakkat), Science and Society 2013: emerging agendas for citizens and sciences [poster], University of Ottawa, Canada.

2012 *The Incorporation of Transdisciplinary Thinking into the Development of Hitchhiking Payloads*. Small Satellite Symposium (Hitchhiking to the Moon), 63rd International Astronautical Congress, Naples, Italy.

2012 *Artistic Practice as a Means for Recognising the Value of Autonomous Spacefaring Activities*, Space and Society Symposium (The Role of Artists in Space), 63rd International Astronautical Congress, Naples, Italy.

2012 *Re-imaging space technology: Encounters with Chandrayaan-1 through art-practice perspectives*, Centre for Contemporary Studies, Indian Institute of Science, Bengaluru, Karnataka India.

2012 Visiting Researcher presentation, Manipal Centre for Philosophy and Humanities (MCPH), Manipal Unversity, Manipal, Karnataka, lndia.

2012 Presentation to research group at Srishti School of Art, Design and Technology, Bengaluru, India.

2011 Seminar presentation, *Translation, space technology and representation* Transtechnology Research Group, Plymouth University,

2011 Visiting Researcher presentation, Manipal Centre for Philosophy and Humanities (MCPH), Manipal Unversity, Manipal, Karnataka, lndia.

2011 Artist's talk, (Secret Satellites exhibition), Belfast Exposed Gallery, Belfast, UK.

2010 *Moon Vehicle Café*, Public Ownership of Astronomy Symposium, Kalpaneya Yatre astronomy festival, Jawaharlal Nehru Planetarium, Bengaluru, Karnataka, India.

2010 *Children's Festivals* (with Prajwal Shastri), 13th All India People's Science Congress, Sreekerala Varma College, Thrissur, Kerala, India.

2010 *Finding Meaning*, Global Lunar Congress (GLUC), Beijing, China.

2009 *Moon Vehicle* (with Babita Harry), International Symposium on Electronic Arts (ISEA), Belfast, UK.

Professional workshops (leader):

2013 *Surreptitious Networks*, artists' professional development workshop organised by CRUMB, University of Sunderland in collaboration with Pixel Palace, Newcastle-upon-Tyne, UK.

2013 *Accessing Imaginaries: drawing, seeing and not-thinking* at Research, Creativity and Business 2 conference organised by The Culture Capital Exchange at Cass Business School, London.

2012 *The History of the Geostationary Orbit* Camps Invisibles: Geografies de les ones ràdio, Arts Santa Monica, Barcelona, Spain.

2011 *Poetics of Satellites* workshop strand leader Orbitando Satélites. Laboral Centro de Arte y Creación Industrial, Gijon, Spain.

2011 *The Satellite Investigators* at Secret Satellites, Belfast Exposed Gallery, Belfast, UK.

Exhibitions:

2014 Republic of the Moon, The Arts Catalyst, The Bargehouse, London, UK.

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Centre for Contemporary Studies, Indian Institute of Astrophysics, Bengaluru, India.

Drishya Kalika Kendra, Bengaluru, India.

Indian Space Research Organisation, India.

Indian Institute of Astrophysics, Bengaluru, India.

ITACCUS International Technical Committee on the Cultural Uses of Space

The Jawaharlal Nehru Planetarium, Bengaluru, India.

Madivaala Government School, Bengaluru, India.

Manipal Centre for Philosophy and Humanities, Manipal, India.

Mullard Space Science Lab, University College London, Surrey, UK.

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Signed ....

Date ....

EXPERIENCE AND VIEWPOINTS IN THE SOCIAL DOMAIN OF SPACE TECHNOLOGY

Frontispiece

As a beginning point, from which the discussion of the thesis cascades, an opening image and accompanying text is first presented, which, in the tradition of the frontispiece, illustrates a central theme and preoccupation of the argument.

Figure 1: Drawing by one of the children from Drishya Kallika Kendra learning centre in Bengaluru made during a Moon Vehicle workshop July 2010 (photo: the author) (*Image reproduced courtesy Drishya Learning Centre*)

An object in space suggests a relation to the whole planet that an object going into the ocean would never attain, imaginatively, even if travelling equally far from the surface of the planet.[1] Spacecraft, rockets, space stations and humans in space have an inescapable quality of being imagined in relation to the whole planet. The image of a rocket or spacecraft next to a planet,

1 Amitai Etzione draws this analogy in the opening to his book *The Moon-Doggle: Domestic and International Implications of the Space Race* (1964) where he says the public imagination would never have been caught in the same way by U.S. and Soviet craft going into the ocean.

and disproportionately large, is characteristic of depictions of outer space made in classrooms, comics and films (Fig. 1). The effect of this ubiquitous type of illustration is to imbue the object in space with equivalence to the planet and perhaps an overburdened significance, as if all those on the planet are implicated in its proposition. At the same time the spacecraft can represent the opposite – a turning away from the planet, a search for solitude, an escape.

The iconic picturing of spacecraft and planet in the same frame form an imaginary equation presenting a symmetry that can either reinforce the logic of cohesion and unity or the logic of escape and disjuncture. If the whole planet is implicated in the logic of the spacecraft then the orbiting spacecraft reflects a planetary aspiration generating further cohesion. And if the whole planet is unequally implicated in the logic of the spacecraft then the imaginary equation may possibly generate cohesion but could equally generate differentiation. The clarity promised by the image becomes misty.

Where is the viewer located in this image? Inside the rocket or positioned in space watching events unfold, or is the viewer simply outside of the image? The drawing presents an overview[2] seen as if from a floating location in outer space. Outside of the picture, the eye which looks at the image and the inner eye which imagines become the hidden protagonist of the image, directing attention to the invisible account of ourselves in the picture.

[2] A phenomenon termed 'The Overview Effect' was coined by Frank White (1998) to explain what he understood as a shift in consciousness that came about when the whole planet could be viewed at once. This idea has received attention through the formation of an organisation called The Overview Institute (http://www.overviewinstitute.org) advocating the benefits to humankind of the view of the planet from outer space, which is seen as offering a compassionate way of comprehending life on Earth. However, the 'overview effect', which is used by White to argue for new civilisations in outer space, misses the colonial expression of mastery implicit in such utopian projections.

Preface

While this thesis is in many ways a reflection on a seam of experience that comes into being coterminously with the production of space technologies, it says very little about my own experiences that have led to this reflection. Instead I have used the thesis for the purpose it is best suited, as an argument that unlocks some underlying determinants that have relevance beyond my own first-hand encounters and can thereby transfer to other kinds of spacefaring and non-spacefaring contexts. Initially therefore, in this preface to the thesis that missing background is described, not only because this will help the reading of the thesis, but because it will allow a fuller acknowledgement of the co-produced nature of the knowledge presented here and the series of opportunities and engagements which I was a part of, and also initiated, from which the motivation to reflect further through a thesis have emerged. It was through these experiences that the central problems with which this thesis deals became apparent. As I hope to make clear through the thesis, agency is a shared and distributed phenomenon through which activities and actions taken by certain persons are invariably done either directly or indirectly on behalf of others. The key engagements that led to this research project came about through the combined vision, advocacy and creative production of many persons and organisations motivated by common goals.

In introducing first some key engagements that led into the research practice of the study there are two aspects initially to draw attention to. One is my gradual realisation that a seam of experience existed within the space technologist workplace that was not being recognised or sufficiently valued. The second aspect is the gradual shifts in my artistic practice made in order to better access this experiential seam and also in reaction to a pervasive inaccessibility of space technologies, space agencies and the experiences available of outer space. After describing this background a fuller account is given of some of the phases of research practice carried out mainly in Bengaluru,[3] but also in workshops in the United Kingdom through which the initial questions of the research study were addressed. The practice-based elements of this thesis research have been substantial and it has been primarily from this first-hand experience that the decisions made on content and argument has arisen.

One engagement that was of significant influence came in 2006 when I received an Arts Council of England International Fellowship based at the Space Sciences Laboratory (SSL), University of California, Berkeley USA. The lab is funded by NASA and builds spacecraft for scientific experimentation and research with an emphasis on solar physics and plasma physics. Much of the work of SSL has a focus on the movement of weather-like systems of particles in the Solar System around the Sun, Earth, Moon and Mars. During my six-month fellowship the STEREO satellites constructed by SSL were launched and set in orbits around the sun from where they took three-dimensional images of solar activity. On the day of launch there was a party and everyone squeezed into the conference room to view NASA TV's launch coverage on the projection screen. About a week later, I was allowed to sit in the Mission Operations Centre and listen to the "boom deploy" process in which commands (lines of computer code instructions) were sent to the satellites named Stereo A and Stereo B. About eight seconds after the last command was sent, jagged peaks appeared on one of the monitors. As the lab Director Robert Lin came bursting into the control room with characteristic enthusiasm there was an excited conversation about how these jagged peaks indicated that the boom deploy had been successful and that a million miles away a thin, eight foot rod carrying instrumentation had extended out from a spacecraft causing it to shudder slightly.

[3] Bengaluru is used rather than the anglicised name Bangalore in the thesis. Bengaluru is the Kannada language name for the city and Kannada is the regional language of the state Karanataka of which Bengaluru is the capital. In 2006 the name Bengaluru was adopted officially by the city although the name Bangalore is still widely used. Indian cities began to change their names after Independence. The renaming of cities corresponds with sentiments after Independence to not use anglicised names and with the establishment in the mid-nineteen fifties of new states delineated linguistically (Karnataka for example is Kannada speaking, Tamil Nadu is Tamil speaking). The changing of names has been gradual and can be traced also to more recent political shifts. The renaming of Bombay as Mumbai in the mid-nineties for instance was advocated by the governing BJP and Shiv Sena political parties and can be seen as part of a shift at that time inline with Hindu-nationalist political agendas.

In observing these events, it was clear that the lives of spacecraft merged the technical with the phenomenological.[4] Sharing the experience of the science teams appeared in many ways impossible for an outsider. The operators who read the instruments had made the mechanisms themselves and drew on their experiences from other missions to build a picture of what was taking place remotely in orbit. That gap between my own inability to connect to the spacecraft and what I thought was a far greater capacity of the scientists to connect to a compelling experience of outer space is an aspect of spacefaring that I have subsequently attempted to open up. What I have come to understand though is that often greater gaps exists for those closer to the technology to adequately process or experience their remote connections in palpable ways, despite having a physical closeness to the technologies that go into space. Some years later a group of students who I was working with in India visited scientists in the mission teams of the Chandrayaan-1 spacecraft and raised this question of whether space scientists had an advantage over others in their ability to make sense of cosmic space. They returned from their visit telling me how struck they were when one of the scientists replied that she thought the scales of the universe remained as unimaginable to them as for anyone else. I noticed how the scientist's reply had made the students feel that their own arts-led, non-scientific inquiry therefore had legitimacy.

The Director of the Space Sciences Laboratory Robert Lin sadly passed away in November 2012. The other memory I have of him is also telling of what it is I have tried to connect to through the journey of my practice and thesis writing. One day when I was walking into the lab, Robert Lin and a crowd of staff and students were coming out and Robert told me to join them. They were going for the infamous Monday lunch outing to a Chinese restaurant. I was fortunate to be sitting at the same circular table as Robert, and, as always took out my voice recorder as he and others spoke of nothing but extraordinary stories of spacecraft. I have a beautiful

[4] Phenomenological is used here in the sense of an interpretation derived from experience. The term phenomenology is used in this thesis in the sense of meaning a relation to direct experience following the work of philosophers Edmund Husserl (1931) and Maurice Merleau-Ponty (1945). The subsequent adoption of the term into research methodologies also supports my approach. For example, Christopher Tilley in his book *A Phenomenology of Landscape: Places, paths and monuments* (1994) and *Interpreting landscapes: Geologies, topographies, identities, explorations in landscape phenomenology 3* (2010) uses the term "landscape phenomenology" to refer to a first-person, direct experience of landscape as a form of primary research from which meaningful interpretations can be derived.

recording of Robert Lin describing the Mars Observer as it came in to the orbit of Mars, scanning the surface using a magnetometer that with each reading defied expectations of the magnetic concentrations present on the planet, proving the validity of the scientist's experiment and their convictions. As a listener, I was struck by how remote space exploration could become centred on the electrifying space of storytelling around a table at lunchtime and by my host's extraordinary relation to their technologies. Lin's captivating telling of the Mars Observer's entry into the atmosphere of Mars held a potency I wanted to understand better.

I thought that my research study would focus on narratives such as this that transferred a technology from the inaccessible distance of outer space to such intimate spaces of conversation and the everyday. In a roundabout way it has. There is a defining element of authorship present in the recording I made of Robert Lin that day in the restaurant and present also in other recordings I made during my time at SSL. While the research study I eventually carried out for this thesis has focused less on the scientist-makers of spacecraft missions, this quality of authoring – or telling a story from one's own point of view – has nonetheless endured. Throughout the study, authorship lingers as a common form of mediation from which connections to spacefaring develop. It has been the location of authoring also in the voice and the viewpoint of particular persons that has guided the inversion I have attempted to produce through this thesis – an inversion of spacefaring from being imagined as an overarching and all-seeing technological gesture to an intimate, human-scale rendering. It has gradually become clearer to me over the course of this research that the medium of authorship, as mission design, or reflective prose, or conversation and the location of authorship, in a restaurant, in a science lab, at a potter's wheel,[5] wherever it might be, can be considered as *loci* of space exploration because they are instances of its authorship.[6] This insight may create a common ground from

[5] A potter's wheel was the focus of a short film made by two students from Srishti during a short course taught by the author called Cosmic Minutes. A shot of the wheel spinning was set to the soundtrack of observations about cosmology made by people the students encountered in a pottery village outside Bengaluru.

[6] Authorship is a term I use through the thesis to indicate an interpretive space that is particularly valued in creative/artistic production. Authorship is a theme developed through the text in order to indicate distributed and accessible agencies, rather than the association with authority that professional authorship can have. For instance, one of my discussions about the term 'authorship' was with Sergio Sismondo whose research has been about pseudo-authorship in the pharmaceutical industry (Sismondo, 2007). In a presentation given at the Science and Society 2013 conference at the University of Ottawa, Sismondo

which to rebuild a picture of what it is that comes into being as a consequence of spaceflight. In this way my understanding of what was potent within the stories of spacecraft that I began to record some years back has developed through the process of research and writing to encompass what I have called in the thesis an affective space of space technologies that is grounded in accessible experiences. The thesis I have written as a consequence, is concerned as much with those working closely with space technologies as with those without satellites.[7]

Part of the problem of my enquiry lay in the effort needed to locate an affective space of spacecraft where agencies lay to interpret, repurpose and author. This required not only gaining access to the scientists working on spacecraft missions, but then accessing within conversations themselves elusive attachments between scientists and spacecraft. The layers of inaccessibility to these stories that mitigated against such a dispersal was also what made them more valuable: not only were spacecraft a technology located at the distance of orbit, a distance made greater by the escape velocity needed to reach it, but those constructing the technologies reaching outer space were themselves sequestered in institutions. Furthermore, those engineers and scientists closest to this almost-direct experience of space-located technologies were cosseted in a language of the scientific workplace that was resistant to the expression of personal experience (Chadha, 2010). At least, personal expression was held within workplace shorthand that was difficult to convey outside of the bonded groups of technologists, scientists and their exceptionally vulnerable, risky and difficult projects. The value of the first-person recollections and descriptions of spacecraft given to me in the Space Sciences Lab was that they cut through

talked about doctors being paid to put their names to reports that were actually produced by pharmaceutical companies and not by themselves. So 'authorship' in his terms was a suspect form of agency. At the conference I presented a poster (with Jobin Kanjirakkat) titled 'Language, Art and Authorship: A comparative approach towards making sense of the science-society question'. While Sismondo was sceptical of the authority placed on authorship, I was looking at authorship in a different way, as an accessible form of agency accompanying forms of artistic creativity, but also present within scientific practices or the making of technology, as expressed for instance in Robert Lin's story of Mars Observer. My comments on this discussion are published in an article 'Science and Society 2013: Some thoughts on the idea of bias and the idea of ignorance' (Griffin, 2013c).

[7] I would like to note my gratitude here to the Brazilian artistic collective MSST, the Movimento dos Sem Satélite that translates as the Movement for those without a satellite. The collective uses the idea of being without a satellite to propose a more penetrating critique of the consequences of space technology than many artists who engage more directly with space technologists and technology, such as myself, can reach. Through their poetic engagements the proposition of being without a satellite sets in place a type of thought experiment that diminishes technocratic power. The group borrows its name from MST, Movimento dos Trabalhadores Sem Terra that translates as the Landless Worker's Movement, an important social movement in Brazil that campaign for land reform, in particular for unproductive land owned by corporations to be returned to farmers.

these layers of inaccessibility: the human voice as an oral history, conveyed an intimate reading of the distant spacecraft and brought, in the moment of telling, an unexpected closeness to the technological object.

During this time in Berkeley at the Space Sciences Lab I used the recordings of the conversations to make an artist's book and also create a performance of sound remixes using extracts from the conversations (Griffin, 2007). In many ways the works as artworks were inadequate because they displaced the problematic spaces encountered in the research process to exibition spaces which themselves had issues of access. The intervention needed, as I saw it, was to open doors to the originating spaces of the space science lab. Artworks created by artists Liliane Lijn and Semiconductor after their own fellowships at SSL do undoubtedly generate vibrantly discursive spaces that transfer knowledge into new domains as well as re-imagining the work of the science lab back to the scientists themselves.[8] My own response though was to develop a somewhat different route in which the making of artworks – their generation, reception and interpretation – was distributed through a different kind of matrix. After the fellowship at the Space Science Lab I developed a number of other projects some in schools and one in another space science lab – the Mullard Space Science Lab, University College London in Surrey, UK. In these engagements I tried different methods of lessening the separations between artworks, producers and receivers. One way of achieving this was to collaborate. In the schools where I led workshops as a visiting artist, group work was a common way of working particularly with middle-school years. When I began to start the project at Mullard Space Science Lab, I had the beginnings of a new method of collaborative working developed in part through the classroom projects. At Mullard I was commissioned to make a work that would forge links between people living in the local villages and the lab employees.[9] After interviewing people from the locality and then the scientists, engineers, caretaker, gardener,

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[8] Semiconductor (the artists Ruth Jarman and Joe Gerhardt) created the film *Brilliant Noise* (2006) after their Fellowship at the Space Science Lab (among other works). The film was made by compositing still images from sun observing satellites of activity on the sun such as CME's (Coronal Mass Ejections) to make moving images. Liliane Lijn, who had a Fellowship at the Space Science Lab in 2005, presented work developed from that experience in an exhibition called *Stardust* at Riflemaker Gallery, London in 2008.

[9] The commission came from the art/science agency The Arts Catalyst and was funded by UCL Beacons of Public Engagement.

administration and kitchen staff at Mullard about their work, I devised a guided walk called *Satellite Stories* (2008). The guided walk was presented entirely by scientists from the lab and local people such that stories of spacecraft and other intrigues were exchanged [Panel 1]. As a result of *Satellite Stories*, scientists themselves at the lab identified that there was a seam of experience within their work that was remarkably unique but for which no shared platform existed.

It was not until I was invited to work as mentor of the Moon Vehicle project as an artist-in-residence at Srishti School of Art, Design and Technology[10] in Bengaluru that I was given the time to develop a collaborative approach to artistic practice more fully. The Moon Vehicle project was initiated as a 'vehicle' to draw out cultural associations of the launch on 22 October 2008 of a spacecraft built in India called Chandrayaan-1 on a mission to the Moon. As I explain more fully in Chapter 4, although a collaborative partnership was sought with the Indian space agency (ISRO) that was launching Chandrayaan, the suggestion to collaborate was refused. So, unlike my fellowship at the Berkeley Space Science Lab where I was given a desk inside the workplace, or at Mullard Space Science Lab where personnel working in the Lab initiated the project, Moon Vehicle had no official connection with a space agency or lab.[11] Instead, it

[10] Srishti School of Art, Design and Technology is one of the preeminent design institutions in India with an international reputation. It was founded in 1996 with funding from the Ujwal Trust, is a fee-paying college and offers post-secondary liberal arts based education. Srishti has a distinctive pedagogical vision in which contemporary artistic practice has a key role with artists' projects feeding into the design curriculum: "Srishti is an institution that engages with the arts and culture at many levels. It supports, through its Artist-in-Residence and Research Associate programmes, the creation of new and critical works in the fields of art and culture. It is a place of design practice, where students and faculty work on real-world projects" (Cumulus, 2011).

[11] Access for foreigners to ISRO sites is not usually permitted, but as Artist-in-Residence at Srishti I had a work visa which allowed me to visit several ISRO bases including the tracking wing ISTRAC at Peenya in Bengaluru, the Indian Deep Space Network south of Bengaluru and also the Public Relations officers in the Department of Space at the ISRO headquarters in Bengaluru. All of these visits required security clearance. I was not allowed to go inside the more secure Satellite Applications Centre (SAC) or to visit the Vikram Sarabhai Space Centre in Thiruvananthapuram, Kerala. My students and the school children I worked with were allowed to visit SAC (also requiring clearance) and here they saw spacecraft being assembled in the clean room. Researching a prestigious and high security institution such as ISRO presents many obstacles. I refer later in the text to Carol Upadyha's paper (2008) on the difficulties she found doing research about high tech company employees in Bengaluru. Itty Abraham begins his book about nuclear technology in India (1998) by saying that he conducted his research through documents in archives outside of India because access was problematic and scientists were anyway restricted in what they could talk about, making an ethnography difficult.

I found many ways to meet snd talk to ISRO scientists who worked on Chandrayaan simply because of the collaborative nature of the Moon Vehicle project. But, importantly, as I develop in the text, I encountered individuals at all levels of the organisation that wanted to share their work and welcomed also, it seemed to me, the chance to speak about their experience. I have respected the informality in

Figure 2

Figure 3

Figures 2 and **3** were taken at the event 'Satellite Stories' devised by the author and held at University College London , Mullard Space Science Lab in Surrey, UK on 3 November 2008. The event was produced by The Arts Catalyst and funded by UCL Beacons of Public Engagement. [**Figure 3** shows engineer John Rose recalling an anecdote about the rivets in a spacecraft. John sadly passed away in 2009. The Cassini-Huygens spacecraft now at Saturn is among the many spacecraft carrying instruments made by John.] (photo credit: Kristian Buus) operated from an art and design college. The project was characterised however by mobility, using multiple spaces within the city of Bengaluru in museums, schools, communities and science institutions. In Bengaluru my research was always conducted with others, usually Srishti students, who brought their own questions and interpretations. This happened in part out of necessity. I had never been to India before and needed guides to know how to interact. Working in such a group-oriented way was also usual practice for the design students and they would generate their own responses through artworks, films and performances as well as part of the shared project. Crucially the fieldwork of the project's processes generated dialogues between the members of the group and also across different communities, disciplines and locations. These dialogues sometimes exposed common ground and sometimes exposed vast shortcomings in the connections of science to society, shortcomings that would have been more difficult to see and decipher from a research perspective situated inside the space agency or science institution.

One strand of the research practice that is relevant to its formulation deliberately focused, not on the spacecraft Chandrayaan and its journey to the Moon, but on the science of astronomy. This shift in focus helped to make clearer the kind of connection to outer space produced through space technology and the kind of connection produced through the study of the science of outer space – astronomy. This helped in separating out different layers to the connection with outer space brought by technologies. What also helped in understanding how different layers of connections to space operated in parallel to each other was to participate in non-institutional astronomy. One of the astronomical events I participated in that had little to do with the organisation of institutional astronomy was observing the annular solar eclipse[12] from Rameshwarem in south Tamil Nadu. I joined a group loosely coordinated by the Bengaluru Astronomy Society (BAS). Members of BAS had constructed makeshift apparatuses that

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which many conversations took place and have not written directly about these conversations because of the lack of clarity always as to what was research and what was friendship. However these understandings that developed through many planning meetings, workshops and events form the background that I use to weigh the argument I present.

[12] During an annular solar eclipse the Moon does not completely eclipse the Sun so rather than creating the dramatic sudden darkness of a total eclipse there is only a slight diminishing of light and drop of temperature during an annular eclipse. Some kind of instrumentation was therefore necessary in order to experience the eclipse and in particular to see the 'wedding ring effect' that happens when the Moon is centred on the Sun creating a ring of light.

projected the image of the Sun-Moon eclipse onto pieces of tracing paper taped onto cardboard tubes, tacked onto telescopes (Panel 2, Figures 4 and 5). The group was joined by others who had come to attend the Swami Vivekananda[13] ashram at the same location and fairly soon the extended group had found other ways to observe the eclipse such as in the shadows cast by the leaves of a tree, or the gaps we could make between our fingers, or through patterns pierced into a sheet of paper (Panel 2, Figure 7). These various apparatuses for seeing the eclipse, invented in ad hoc ways during the hour of the eclipse, helped in distinguishing a spectrum of interventions for viewing the skies – from adapting our hands into types of lenses to the establishment of astronomy institutions. The spacecraft was then another kind of mediation within this spectrum.

Astronomy institutions mediate connections with cosmos and to investigate this I ran a short three-week course at Srishti called Cosmic Minutes, which I led with the Argentine filmmaker Nicolas Grande. The class opened up aspects of the problematic that institutions and apparatuses introduce to connections with cosmos. Students reflected on their own understanding of cosmology and then visited various institutes of astronomy in Bengaluru where they encountered scientific and instrumental approaches to cosmology.[14] In the Cosmic Minutes class students were asked to make one-minute films in response to the interpretations they encountered. These experiences and the immensely thoughtful journeys created with students, colleagues, scientists and many others formed the environment of knowledge from which I drew a path for the thesis. The path the thesis takes, substantiates the reasons for these projects and interventions that at the time felt necessary on a more intuitive level for the participants, but where regarded often as unnecessary by the institutions solicited.

The vulnerability felt by the art and design participants during these forays into science and technology workplaces may be sensed through the thesis. There were for instance constant

[13] Swami Vivekananda was an important figure as a spiritual leader, teacher and writer and his speeches and writing have been published in nine volumes. In 1893 he spoke in the United States at an international meeting of religious leaders (the Parliament of the World's Religions, Chicago) of the Hindu faith and this speech is often cited as seminal in informing a wider international community of the Hindu faith, in particular he put forward the notion of Hinduism as monotheistic and he spoke of the philosophies of *yoga* and *Vedanta*.

[14] These included the Indian Space Research Organisation (ISRO), the Indian Institute of Astrophysics (IAA), the Raman Research Institute (RRI) and the Indian Institute of Science (IISc).

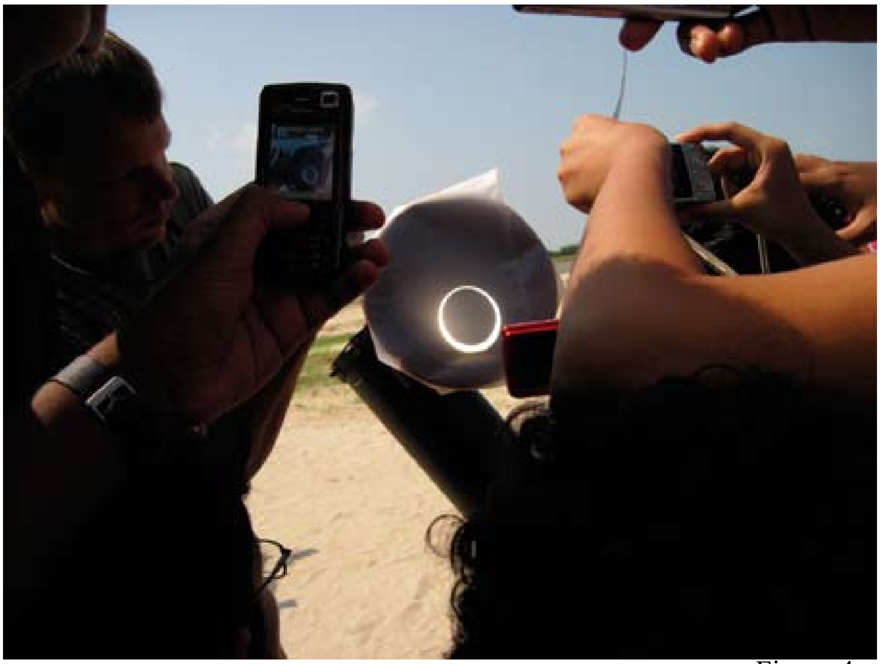

Figure 4

Figure 5

Figure 6

Figure7

Figures 4-7 were taken by the author during the Annular Solar eclipse on 15 January 2010 near Rameshwarem in Tamil Nadu, south India. Members of the Bangalore Astronomy Society set up their adapted telescopes to aid in viewing the eclipse (shown in **Figures 4** and **5**). Attendees at the Swami Vivekanada ashram shown in **Figure 6** also joined the group. **Figure 7** shows how children used their hands to focus the image of the eclipse. (photos: the author) administrative difficulties in gaining access to the various institutions that jeopardised the possibility of fieldtrips. A visit to one of the astronomy institutes was greatly delayed by the Director's concern that science would be misrepresented in the student's films. The film project, in some ways was indeed a ruse to gain access to the workplace and find out more. The Bengaluru based anthropologist Carol Upadhaya writes of using filmmaking for a similar reason in her research study of workers in high tech companies in Bengaluru (2008).[15] When the Cosmic Minutes films were screened at one of the science institutes the frictions involved in attempting to explore the apparent common ground between disciplines were brought to the surface. The students were confronted with many questions as to their intentions in entering into what was seen as a superficial critique of a field they were not qualified, as artists, to enter. The fact that so many encounters with scientists did take place is evidence though of the amount of interest there was in forging such connections and some of the reasons for this have been made clearer through the thesis. One reason was that direct encounters with science institutions were almost the only way to uncover the structural obstruction of critique and interpretation of scientific knowledge and practices. It was felt by some both within the institutions and outside that this contentious space needed opening up for discussions of the social consequences of scientific knowledge and practices to take place.

One of the findings of this period of research was to notice how space technology would lose its relevance within discussions of astronomical science. The focus given in the thesis on the spacecraft Chandrayaan and its potentially unbounded affective space distorts what in many ways was the negligible importance of the event of its launch. This is a reality that recalls the depiction of the fall of Icarus in a painting attributed to the sixteenth century Dutch artist Pieter Brueghel. In this painting the legendary fall is rendered a small splash in the background of the more present concerns of the everyday and is perhaps a good analogy of how the spacecraft's launch actually registered in people's lives more generally. As the poet W.H. Auden suggests in his poem *Musée des Beaux Arts* (1940) that offers a reflection on the painting, perhaps the man

[15] In this paper Upadhaya writes of resorting to making an ethnographic film in order to buy time "hanging around" (2008, p. 67) her subjects in order to understand their perspectives better. In her initial interviews she felt employees only spoke as company employees and she wanted to find a way to access their more personal histories and situations.

plowing the field in the foreground did see Icarus fall out of the sky, “But for him it was not an important failure”. In a similar way, the affective space of the spacecraft Chandrayaan triggered by the success of its launch is inherently speculative. What I have tried to do is indicate where a range of affect emerges that can be evidenced to some extent. This can include the unforeseen, the fragile as well as indifference as values on that range.

There is much more still to tell of the experiences and activities that have informed this study, but for brevity I will mention only Kalpaneya Yatre festival of astronomy that was another of the many substantial elements of the research practice of this thesis not included. The Moon Vehicle project was instrumental in raising an agenda of concerns that led to the production of a festival of astronomy called *Kalpaneya Yatre: Journey of Imaginations*[16] held 25 November - 5 December 2010. The festival was a mammoth undertaking for all involved and took more than a year to plan and produce. The events, activities and networks of communities formed through the Moon Vehicle project enabled the creation of a new transdisciplinary network that could take the steps to fundraise, manage and produce the festival.[17] During the Moon Vehicle workshops some of the scientist participants noticed a way to realise their own intentions to create a public forum to share the science of astronomy. They saw in collaboration with the art and design college a means to produce a public science festival that would convey science out of their institutions and workplaces and at the same time bypass the official public relations channels that in too many ways were falling short of their duties.

The festival could be the focus of a thesis in itself. It was stated to be the only time in India that such a public astronomy festival has taken place and as well as thousands of visitors also brought the interest of key figures from Vigyan Prasar, the government administration wing of public science and elsewhere. Part of its extraordinary achievement was that the festival made

[16] The title *Kalpaneya Yatre: Journey of Imaginations* is bilingual – in Kannada and English languages. The entire exhibition installation was written in bilingual text because Kannada is the official language of the state of Karnataka in which the festival took place. There was a great deal of press coverage of the festival at the time, which had around 3000 visitors a day over ten days. Srishti alumni N. Poomulli produced a video (2011) of the festival with interviews of the author and others involved and the Preliminary Report written by the host institute, the Planetarium is available online (Jawaharlal Nehru Planetarium, 2010).
[17] The institutions that worked together on the event were Srishti School of Art, Design and Technology, the Indian Space Research Organisation, the Indian Institute of Astrophysics, the Jawaharlal Nehru Planetarium, the Raman Research Institute and the Visvesvaraya Industrial and Technological Museum.

much clearer who the stakeholders in the public dissemination of science were – museum curators, science popularisers, affiliates of the All India People's Science Network, scientists from the many institutions in Bengaluru, amateur astronomy clubs as well as art and design practitioners and college students. My own role in the production of the festival was significant.[18] I particularly argued for the importance of dialogue during the ten days of the festival and exhibition emphasising the need to create forums where exchanges could take place that did not privilege the scientists' viewpoint and the discipline of science. My concern was to provided spaces to synthesise through conversation and exchanges of different kinds the unimaginable scales and significance of the cosmos that the festival presented.

In India though, science popularisation has already created a substantial valuing of science within a general social field, so the many kinds of interactions that took place, although appearing to privilege science, were actually far more syncretic reflecting the deep cultural bonds in India between science and society. Sessions took place such as question forums called 'Ask an Astronomer'; there were lectures about black holes and science of the Sun and scientists wandered through the exhibition on hand to talk to visitors. Education workshops took place including one titled 'the universe with a string and a stone' run by the Mumbai based science popularisation organisation Navnirmiti. Funds were raised to bring school children in from rural areas and for teachers to receive training that they would then 'cascade teach' to others.[19] An entire area of the festival, which was dedicated to explaining the science of multiwavelength

[18] With colleagues at Srishti we developed an umbrella project called Cosmic Conversations in which around a hundred students took part. Their work created the exhibition design for the festival. I led a project called Design for Dialogue (within Cosmic Conversations) with Deepak Srinivasan and students Gauri Singh and Rajasree Ray involving sixty children at Madivaala Government School and scientists from the Indian Institute of Astrophysics (the Institute had 'adopted' this neighbouring school). Some of the children's work was transformed into huge spacecraft lanterns that hung in the trees during the festival and were built by the eco-construction team Green Chakra. I also led a second workshop at the Drishya Learning Centre for children, which was about imagining the Moon (described in the article 'Hitchhiking to the Moon' included as Appendix 3). The children presented their work at the festival to other children. As a member of the festival programme committee I arranged for ISRO Director Shivakumar to give a lecture titled 'The Story of Chandrayaan' and organised the film festival curated by Shai Heredia and titled Projected Utopias. I also organised an evening event for artists and astronomers inviting the artist Rohini Devasher to speak and also the leader of the Bangalore Astronomy Society, Naveen Nanjundappa. As part of a symposium on the last day of the festival titled 'Public Ownership of Astronomy', I created a lecture/event entitled Moon Vehicle Café in which everyone sat in concentric circles under a projection onto the ceiling of the Moon, eating food and conversing about the Moon. These were all interventions designed to offer space for dialogue.

[19] These sessions were led by BGVS (Bharat Gyan Vigyan Samiti or Indian Organisation for Learning and Science) that organises science teacher training through the state of Karnataka.

astronomy, was run entirely by children who demonstrated aspects of the physics of the universe with various props. Leading into the festival I ran workshops on the theme of 'Moon analogues' (Griffin, 2012, see Appendix 3) with children from Drishya Learning Centre who gave a presentation to other children during the festival. At another school neighbouring the Indian Institute of Astrophysics, I created a project around the theme of satellite stories. With these children and a team of bamboo designers we constructed giant spacecraft out of bamboo that were hung in the trees and illuminated at night. My co-workers on the project devised a performance that ran for three evenings during the festival that led into audience discussions about science and biography, which were usually heated and could be heard continuing in conversations through the days of the festival. I asked the Bengaluru based film curator Shai Heredia to create a film programme that she titled 'Projected Utopias' which included important short films from Films Division India such as Pramod Pati's *Explorer* (1968) and a rare film about the early space programme in India called 'Space and India ' (1971) by the colleague of Pati and similarly authorial filmmaker Vijay B. Chandra. Heredia herself had found the reel in a market. The film included footage of Vikram Sarabhai, often called the father of India's space programme, and other scientists who were identified by members of the audience, many of whom were from the spacefaring and astronomy communities. This film turned out to be immensely useful in my analysis for understanding how the imaginary of a societal space programme in India was shaped (see Panels 4 and 13 and a transcript of the film in Appendix 4). But the anecdote about the film found in the market is a revealing example of the serendipitous ways that research materials became available to me because of my involvement in the festival. The experiential research that I devised both informed and generated the reflection on the mediation of technological practices across disparate social fields developed in the thesis.

This leaves then a final aspect of this research study that hovers as a question throughout and which I sense marks the beginning of my future research. This, at its simplest is the question of how a foreigner might see and interpret, but at its more useful and expansive becomes the question of what kind of research imagination can be claimed by crossing continents.[20] It is the disruptions and the inconsistencies that I have found in the crossings I have made mainly between the UK and India and more specifically between Plymouth and Bengaluru, that has been the joy of this thesis research – bringing the exceptional opportunity to think, practice and write from distinctive locations with different ways of being in the world. It is through the disruptions and inconsistencies in academic consensus that I have been exposed to that I have come to understand the realities of the asymmetries by which discourses are constructed and the ever-present problem of a consistent favouring of what is sometimes referred to as Euro-American discourse. My project is arguably postcolonial, while not engaging overtly with the postcolonial field of discourse, I have steered the course of this thesis into distinctly troubled waters confronting not only, on a personal level the limitations of my own viewpoint but also dislodging common renditions or master narratives of spacefaring in which the Indian space programme would be relegated to at least a secondary position. Centering the question of the accountability of spacefaring on the actions of the Indian space programme has been uncannily productive, enabling a mode of reflection that has produced a resilient set of answers. The core failing in making such an attempt to cross-continents and dislodge certainties is that my own experiences and deep cultural ties bound the argument and reflection of the thesis. So for instance, the meaning I give to words such as 'intimacy', ‘family’ and 'society' stems from my core experience and can only partially be re-informed by shifts in living spaces and exposure to discourse. It was kindly pointed out to me for instance at the end of my presentation *Re-imagining Space Technology* at the Centre for Contemporary Studies in Bengaluru that the idea of intimacy that I used to reflect on the affective realm of space technologies might not correspond with an experience in the Indian context of intimate space.[21] I have to keep an open

[20] Arjun Appadurai raises questions of the "research imagination" in relation to mobility, flows and migrations experienced as forms of globalisation and the disjuncture of such experiences from the academic conceptualisation of globalisation produced through research in the essay 'Grassroots Globalisation and the Research Imagination' in the book *Globalization* (2001). Raewyn Connell's book *Southern Theory* (2007) lays out similar problems in the circulation of theory between the 'metropole' and the 'periphery'. Her work illuminates my own commitment to working with theory coming from, or concerned with, the Indian subcontinent in order to understand issues that surfaced during the Moon Vehicle project conducted in Bengaluru. See also Kenway and Fahey (2009) *Globalizing the Research Imagination*.

[21] "Re-imaging space technology: Encounters with Chandrayaan-1 through art-practice perspectives", 15 March 2012, Centre for Contemporary Studies, Indian Institute of Science, BangaloreBengaluru, India.

mind therefore about what such terms may mean in the world and acknowledge that here in these kinds of meanings there will be shortcomings in my interpretations that I hope will be transparent enough in the text to be adjusted and accommodated.

Introduction

Questions, aims and contribution

This thesis responds to the broad questions about spacefaring: Who is it for and what is it for? That these questions have many answers was alluded to by the leader of the Indian space programme Vikram Sarabhai in 1966 when he said "man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed" (1966, 2001, p. 92). He was referring to the attempt to reach the Moon by the United States space programme and the rhetoric with which the US President John F. Kennedy claimed that space exploration was an endeavour for all humanity. In a now famous speech given at Rice University in 1962, Kennedy announced the Moon missions in the context of the search for knowledge, saying "We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people". Yet Kennedy spoke in the terms of a narrative of exploration deriving from an experience specific to the United States, referencing the landings of the pilgrims at Plymouth, Massachusetts and using sentences such as "This country was conquered by those who move forward – and so will space", which call into question the ability to speak and act for all people, either through political speeches or acts of spacefaring. In its formational years, the Indian space agency that began also in 1962 established an important critique of the purpose of spacefaring by defining an alternative 'societal' purpose for space technologies. It was a programme in which space technologies were applied to pressing problems on Earth and specifically the Indian nation. This thesis follows the lineage of the Indian space programme by continuing its formational critique of the purpose of spacefaring by addressing similar questions in new ways.

The central focus of this thesis is on understanding a set of forces around an artist-led interaction with the Indian space agency. Restoring the experiences, activities and motivations of that interaction into a much larger field of influences that at the time of the interaction was only partially seen and understood reveals this set of forces. The Chandrayaan-1[22] spacecraft 's mission to the Moon is used as a key example of space technology in the study. Chandrayaan was launched by the Indian space agency, which is called ISRO (the Indian Space Research Organisation) on 22 October 2008 on an expected two-year mission. Contact was lost with the spacecraft on 29 August 2009. The Chandrayaan spacecraft's mission to the Moon appears to renege on the formational philosophy of the Indian space programme not to be drawn by the mixed motives of interplanetary missions but focus instead on tangible connections between the Indian people and space technology. The link that can be made between the Chandrayaan Moon mission and the speculation about the ambiguities of Moon missions by the programme's founder Vikram Sarabhai however provides a fault line. This fault line is used in the thesis to open up the questions of who spacefaring is for and what it is for in order to probe ambivalence in the rhetoric, activities, images and imaginaries of spacefaring.

Aspects of the mission related in this thesis were accessed largely through an art project called Moon Vehicle that was led by the author and ran alongside the Chandrayaan mission. Through this artist-led project it became evident that the spacecraft held substantially different meanings for different constituencies that came together during the workshops, events and activities of the Moon Vehicle project. This revealed a convergence of often incommensurable viewpoints of what and who the Chandrayaan space mission was for, which largely confirm Sarabhai's misgivings. The empirical findings of the project are thereby used to revisit the claims made of the purpose of spacefaring. In so doing it becomes apparent that there are significant missed components in accounts of the purpose of spacefaring that appear in space agency and other government or official rationales. Qualities associated with first-person experiential viewpoints are shown through the thesis to be a missed component in the accounts habitually made of spacefaring. The thesis shows how artistic or creative approaches open experiential dimensions

[22] The Chandrayaan-1 spacecraft will be referred to as Chandrayaan in the text. The Chandrayaan-2 spacecraft is in production.

and foreground first-person viewpoints that evidence heterogeneous interpretations, appropriations and affects of spacefaring in disparate social domains. The thesis argues for the recognition of experiences and viewpoints other than the direct experience of outer space attained in human spaceflight, so the first-person accounts of astronauts are not dealt with directly although they can be encompassed within the argument.[23] The thesis instead calls attention to a wider field of indirect experience, affect and uses of space technologies than is usually presented.

Qualities of creative authorship that became apparent through the artist-led approach adopted in the Moon Vehicle project are used in the thesis to provide a fuller picture of the mixed motives of spacefaring and to indicate spaces where agencies exist to re-imagine and critique space technology. This leads into a proposition, which forms a key part of the original contribution of the thesis, for how space technologies and their affective spaces can be seen, imagined and thus accounted for. This is done through a close examination of how visually oriented practices and thinking construct and intervene in the production of spacefaring imaginaries. Both the methods of the inquiry and the thesis contribution have transferability beyond the example of space technology to contexts affected by large technological systems.

The Problem

An initial premise framing this inquiry is that space technology at once gives access to a previously unattainable direct experience of outer space but that at the same time the necessary organisation of space technology production sets up a restrictive conduit to that experience. Furthermore, through the organisation of space agency programmes, effects emerge beyond the site of the space agency, which include a devaluing of previous, non-technological or other kinds of connection to space. The problem addressed in this thesis concerns disjuncture evidenced within social relations linked to the technological projects of spacefaring. This

[23] See for example *We Seven* (1962) that gives accounts by seven astronauts of the US Gemini programme and Andrew Smith's *Moondust* (2005) in which he tracks down and interviews the astronauts who walked on the Moon as well as astronaut's memoirs such as Buzz Adrin's *Return to Earth* (Aldrin & Warga, 1973).

disjuncture can be best described as happening within an affective space. Affective space is used here to conote the proximal qualities of experience by which sense is made of the world. It acknowledges the ways that shifts in the physical world are also part of the emotional and cognitive realm and that influences can be visible and invisible, material and immaterial. Affective spaces are fraught with asymmetries. An example used in the thesis calls attention to the difference in experience between persons working at a rocket launch site and those living nearby, in which the affective realm of the person inside the space agency – their values, goals, wishes – are found to be more easily prioritised over the values, goals and wishes of those not a part of the space agency but living nearby and adversely effected by its activities (Gorman, 2005a, 2007; Redfield, 2000). The nature of such affective spaces are complex and therefore more easily overlooked and particularly so when in comparison to the spectacular materiality of a rocket launch site there is little visible evidence of the interruptions that are experienced outside of the space agency.

It is suggested in this thesis that the spectacular visuality of spacefaring has been overlooked as a determining factor in how spacefaring is accounted for and what is included and left out of the picture. The apparatus of space technology draws the attention. Photographs and TV coverage of launches inevitably focus on the rocketry and rarely observe the local environments in which they take place. Yet the spectacle and apparatus of spacefaring is also deeply connected with a topography of experiences within affective spaces that are mostly hidden from view. A few researchers such as the cultural archaeologist Alice Gorman, the cultural geographer Peter Redfield and the media theorist Lisa Parks have studied some of the more troubling affective spaces of space technologies. These studies begin to introduce new ways of talking about space technologies from humanities perspectives. Adding to this new field, the proposal of the thesis is that disjuncture manifested in social relations that occurs through the technological projects of spacefaring would be better understood, and thereby addressed, if methods can be found for seeing better the mechanisms causing disjuncture. What the thesis finds is that a form of visual analysis, suggested by the processes of seeing located in the artist-led approach of the inquiry provides a methodology with which to address this problem of disjuncture by enhancing its visibility.

The thesis begins by addressing a generalised claim by space agencies, which is a problematic assertion, that spacefaring serves humanity. This claim implies firstly that an account can be made of humanity and secondly that all are in some way complicit in the enterprises of spacefaring. The thesis contributes a means of seeing a missed component in that account of for who spacefaring is intended by using insights from the artist-led practice used in the research process. It is argued that by replacing the collective nouns humanity, society or public – most commonly used in the justifications of spacefaring – with the notion of viewpoints, less generalised categorisations can be developed that accommodate diverse appropriations and interpretations of spacefaring. The emphasis given to viewpoint, seeing and direct experience enables a key move to be made in the thesis of drawing attention to the heterogeneity of first-person viewpoints as a missed component in the account of spacefaring. Using insights from subaltern studies, suggestions are then made as to how this missed component can be brought back into the purview of spacefaring. It is argued that a richer understanding of the particularities of viewpoints is key to solving problems of accountability on which some assertions of the purpose of spacefaring falter. However, it is also argued that 'being missed' may not always be detrimental and that as an alternative position 'not wishing to see the whole' or acknowledging that the whole cannot be seen, known or summoned as a conceptual category is a more workable strategy. This strategy of accepting partial knowledge and mixed motives is, paradoxically, a means by which an affective space of spacefaring is seen more easily.[24]

[24] See Alberto Toscano's article 'Seeing it Whole: Staging totality in social theory and art' (2012) for a discussion that proposes social scientists should learn from the ambitions of some artist's projects to push for theories and methods that do try to grasp totalities. He suggests that social theorist Bruno Latour's (1993; 2001; 2005) emphasis on fragmentation and partial sight available when social relations work through networks should be challenged with more ambitious theories that do attempt to grasp the whole. Toscano uses the example of the panorama as an artistic genre that demonstrates the kind of ambitious imagination he proposes and he references the "cognitive mapping" (p. 80) of contemporary artists Mark Lombardi and Allan Sekula. Lombardi made collossal drawings of connections underlying power stuctures, (such as connections between politicians and terrorists through oil business). Toscano's call to 'see it whole' moves in the opposite direction to the proposition here of accepting partial knowledge. His argument runs against the my thesis in which I take the idea of artistic authorship to indicate a space of interpretation that resists the total view and instead draws attention to distributed incidences from where there is limited ability to see the whole. Yet Toscano's argument also overlaps with my own in the

i. Space agency claims

One source of the problem lies in the language and imaginaries used by space agency professionals for talking about the rationales, justifications and benefits of the space industry. Illustration Panel 3 shows two trade show stands (Figures 8 and 10) at a space industry conference and a promotional bag (Figure 9) displaying the commonly used taglines with which space agency products are repeatedly promoted through aspirational phrases such as "Space for Earth", "Touching Humanity" and "For the future of Planet Earth, for the Living Creatures of this Planet". Such phrases reveal the allure of a space technology that is imagined as something that develops the whole of humanity or the planet. They are phrases used to market products that sustain a space industry. The promotion of the idea of spacefaring to social domains not involved in buying space technology products often proceeds though from a similar perspective that universal benefits are provided through space technology and exploration.

As one example of this tendency, at a conference plenary session titled "Moon for Society, Public and Youth" held at the Global Lunar Conference 2010 in Beijing five speakers briefly presented their thoughts on how to engage publics with space and why.[25] The first speaker, a Chinese taikonaut (the term used in China for astronaut) presented a frequently voiced, extreme scenario in which if all resources on Earth ran out humans would need space flight to find another planet to live on.[26] The idea that spacefaring could save the human species was often voiced by scientists working on the space missions encountered during this study as the ultimate

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recognition that there can be in artistic vision an ambition to develop strategies for seeing that defy existing modes of image-making and imagining. Toscano's call for an overview is not at the expense of "oversight" (p. 65) and it is towards exposing 'oversights' or 'missed components' that the thesis is addressed.

[25] I also presented at the Global Lunar Conference 2010, in the education symposium, which was chaired by two members of the plenary panel described. My presentation was about the Moon Vehicle workshop held at Drishya Learning Centre, described in Chapter 4 and also in a paper (Griffin, 2012, this paper is included in Appendix 2).

[26] The connection between spaceflight and species survival is commonly voiced amongst space professionals. Bernard Foing, the head of the International Lunar Exploration Working Group (ILEWG) writes of space technology as a Noahs's Ark (Foing, 2006). The essay while a speculative thought experiment, presents scientists stationed on the Moon as the progenitors of a new phase of life after the catastrophic destruction of Earth. This is a pervasive idea that has a primordial quality captured for instance in the imagery of the film *2001: A Space Odyssey* (Kubrick, 1968) in which a human embryo floats like a spaceship through space.

Figure 8

Figure 9

Figure 10

Figures 8 and **10** are Exhibition Hall stands at the 2012 International Astronautical Congress held in Naples. **Figure 8** shows the French space agency stand which displays the tagline "Space for Earth. **Figure 10** shows the Japanese space agency stand and displays the tagline "For the Future of Planet Earth, for the Living Creatures on This Planet!". **Figure 9** shows a sticker on a promotional bag given out at the International Astronautical Congress in Valencia (in 2006). It is advertising the next Congress in Hyderabad (held in 2007) and displays the tagline "Touching Humanity". (photos: the author) rationale for their work. The second speaker was the education officer from the European Space Agency (ESA), who said "Our mission at the education office is to ensure that in the future Europe has a suitably qualified workforce for undertaking its programmes". As an example he explained how the European Student Moon Orbiter project had been devised specifically for students in universities and schools who would construct a satellite and determine its mission. The proposal had come he said from students, not from ESA itself, but for the space agency its investment in the project could be justified in terms of developing a skilled workforce for the future. Speaking for the activities of the commercial enterprise Lunar X, which offers a prize to the first commercial mission to the Moon, the international team's coordinator spoke of the need to educate a "global public", saying "The first thing that we all need to start by doing is educating the global public about the importance of space," and she backed this up by stressing the opportunity this would give to promote mathematics and science education as well as developing the production of space technology. Next, the outreach coordinator for the Lunar Explorers Society referenced his personal experience of being inspired by spaceflight at the age of seven and subsequently becoming a space engineer for the company EADS Astrium. He went more bluntly to a central preoccupation of those in the space industry concerned with public relations saying "We don't have a job if the public doesn't support us". For him the key to this support and the generation of a future workforce was to start early "with very young kids ... they've got to hear about how exciting space is". At the end of the session there was no time for questions, so the language used, its imaginaries and assumptions had the status of statements rather than negotiable positions.

The messages of all the speakers naturally came from a combination of their own viewpoint as space enthusiasts and their positions as employees of the space industry. Besides a natural evangelism for all things to do with space, each also had a specific job to do within their organisations of developing and promoting the concept of spaceflight in order to sustain and build that industry. Within these elisions of motives repetitions appear in their statements, of rationales that are primarily self-serving. Education and outreach are activities that space agencies are involved in because that will produce a future workforce. In these scenarios the public is imagined as taxpayers who provide funds for the space industry and also as human capital that will extend its workforce. But repetitions of self-serving rationales are made also because of a lack of vocabulary for dealing with the concept of an 'other' – a people not part of the logic of the space industry but affected by it, or in need of being affected by it, or educated by it. The problem of conceptualising this 'other' is glossed over in vocabularies such as "global public" and in loose, questionable strategies such as 'catching them young'. Anecdotally, scientists and engineers put in roles of education and outreach officers see these as career sidesteps and of lesser importance than the work of making space technologies. This compounds the creation of education and outreach departments inside space agencies that produce an image of a public that is defined by its otherness from the workforce of the space agency but at the same time in need of becoming more like the space agency workforce.

Space agencies such as the United States National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) go to extraordinary lengths to make their work comprehensible and accessible to wider publics. Their Websites are aimed primarily beyond their own workforces to a more general audience. However, the terms by which these space agencies attempt to relate to wider publics through their 'outreach' activities have the paradoxical effect of reinforcing separations between workforces and other social domains by reifying a difference in cognitive space: A difference in which the cognitive space of the space agency scientists takes on a subtly superior position. The sociologist of science Brian Wynne notices a widespread assumption in the field of science communication of a "cognitive deficit" (1991, p. 113) in that "Science communication is normally ignorant of its own tacit "body languages" of institutional interests, which nevertheless constitute an essential part of people's interpretations of and response to that knowledge" (1991).[27] The beliefs conveyed by the

[27] See also discussions on the expert/lay divide. Brian Wynne's chapter 'May the Sheep Safely Graze - A Reflexive View of the Expert Lay Divide' (1996) and Frank Fischer's *Citizens, Experts and the Environment. The Politics of Local Knowledge* (2000) are examples of studies that questions the idea of who the expert is, what constitutes expert knowledge and whose knowledge is undermined. The Moon Vehicle project that is studied through this thesis in many ways can be understood as a practice that questioned the expert/citizen divide. It was a project that fostered the development of shared activities as a way of dissolving or bypassing such divides. For instance in staging a festival of astronomy (referred to in the Preface) the collaborating partners needed each other's expertise. The title of the festival reflected a cultural and scientific overlap of the interpretive space of cosmos –Kalpaneya Yatre: Journey of Imaginations Festival of Astronomy. Yet, despite the collaborative effort, the festival was deemed to be

representatives at the Global Lunar Conference arguably have deeper roots in the very notion of what science is, what scientists do and how scientific practices interweave social spaces.[28] One aspect of this is that philosophically, science is associated with notions of the establishment of facts about the world, which suggest in their expansion that the world consists of s single reality (sometimes called a 'positivist' view), one which only scientists can translate (Sarukkai, 2002). Despite the recognition within discourses of at least the last decade that the assumption of a "cognitive deficit" within publics misses the many valuable reasons for resistances towards scientific knowledge, in practice the assumption remains strong leading to a defining asymmetry in the transactions of science and technology into wider social domains.[29]

'scientific' and other ways of knowing, although richly represented, were somewhat undermined as astronomers (not artists, educators, religious leaders etc.) walked around the exhibition wearing badges inviting visitors to "Ask an Astronomer".

[28] For literature on the question of what science is (from broadly humanities perspectives) see *The Golem: What everyone should know about science* (1993) by Harry Collins and Trevor Pinch; *The One Culture? A conversation about science* (2001) edited by Jay A. Labinger and Harry Colins, *Never Pure* (2010) by Sreven Shapin and *What is Science?* (2012) by philosopher of science Sundar Sarukkai. For a revealing study of science that looks at how language is used in science practices see *Translating the World: Science and language* (2002) also by Sarukkai. From a history of science perspective *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (1985) by Steven Shapin and Simon Schaffer is a seminal work that delineates how scientific facts became associated with empirical observation and corresponds with a new valuing of rationality associated with Enlightenment thinking. The field of Science and Technology studies and the sociology of science have contributed many insights into the social and cultural aspects of the question of what scientists do. These include many ethnographic studies, such as *Beamtimes and Lifetimes* (1988) by Sharon Traweek in which she tracks the routines and values of scientists in a particle physics lab. Work such as this is indebted to the seminal book *Laboratory Life* (1979), an anthropology of a laboratory by Bruno Latour and Steve Woolgar that wrly inverts the habitual anthropological study of pre-modern cultures (see Chapter 2 for a discussion). What is notable about these studies is that they highlight the worldmaking that takes place through the practice of science in which the shared values and beliefs of the community in question become amplified and projected. The political psychologist Ashis Nandy shows how the amplification of the values of science reach an imperialist scale in India and are used to justify the development of large-scale technologies and industries that have had increasingly hazardous consequences for populations (Nandy, 1988) (see Chapter 2 for a discussion). The belief that there are universals (expressed for instance as laws in physics) appears profoundly attached to the question of what science is, whereas science practices are themselves extremely heterogeneous across fields and sub-sections of science practices. For a general introduction to the questions raised by these fields in relation to the interplay between science and wider publics see Sergio Sismondo's *An Introduction to Science and Technology Studies (*2010). For discussions of scientific practices in colonial India see Deepak Kumar (2006) and Kapil Raj (2007) and Raina & Habib (2004). For discussions of postcolonial science in India see Gyan Prakash *Another Reason: Science and the imagination of modern India* (1999); Itty Abraham 'Postcolonial Science, Big Science, and Landscape' (2000). The television series *Bharat ki Chapp* (1989, translates as 'Identity of India') is also a useful guage of currents of debate about science in India establishing science as a fact of everyday life as present in the domestic kitchen as in ancient mathematical and scientific practices of India.

[29] For commentaries and overviews of public engagement with science and technology see Jane Gregory and Steve Miller *Science in Public: Communication, culture, credibility* (1998) for developments charted mainly from the perspective of the UK. From a European perspective see the report 'Taking European Knowledge Seriously' (Felt and Wynne et al., 2007). See reports by the Center for Advancement of Informal Science Education (CAISE) (Bonney et al., 2009) for views from North America where the notion of 'citizen scientist' has been coined and been widely adopted elsewhere. In India the People's Science Movement takes a strong position in advocating for science in India to be used to address societal

Words and phrases like "society", "public", "them" and "young people" structure and naturalise habits of thinking about whom spacefaring is for and what its purpose is. One of these habits of thinking is to divide those who are convinced by spacefaring from those who are ignorant of its worth. Making the public convinced of the worth of spacefaring becomes a key theme in the language used by space agency officials. One of the consequences of this is that it leaves no space for a kind of non-participation that is a deliberate choice or mode of dissent. The lenses of experience and viewpoint, however, reimagine such divisions as far more permeable, misty and complex images that are more resistant to the habits of thinking exemplified by the speakers at the Global Lunar Conference in Beijing.

Nonetheless, the rhetoric and vocabularies most commonly produced from within the workspaces of the space industry perpetually and unconsciously belittle those outside of this community. From the perspective of the space industry the global public consistently 'needs to be educated' about space matters and is placed in an asymmetrical position of ignorance. That position is sustained until it is challenged.

ii. Artist interventions

In recent years a challenge of sorts has come from the arts and humanities. While space agencies such as NASA created on their Websites and through the work of their outreach and education officers opportunities by which the public could participate and learn from space activities and technologies, artists and groups of artists attempted to forge opportunities for themselves. An example is the attempts by artists to experience zero gravity parabolic flights used for training astronauts. Two separate groups of artists between 2000 and 2005, one group flying with the US space agency NASA and the other flying with the Russian space agency from Star City, Moscow, managed through careful and persistent negotiations to create an opportunity to experience zero gravity. The opportunities were designed specifically around the

needs. For a commentary on the People's Science Movement in relation to other political movements in India see Patrick Heller's chapter in *Social Movements in India: Poverty, power, and politics* (2005).

needs, ambitions and curiosities of the artists involved.[30] Amongst these artists were the dancer Katsuo Dubois who investigated movement in zero gravity and from her investigations was able to provide new techniques for training astronauts. Other artists such as Sarah Jane Pell have also been able to develop long-term associations with space activities demonstrating tangible reasons for the inclusion of artistic insights and methods within the space industry. However these efforts at inclusion were hard won and the difficulties these groups encountered initially in forging opportunities for alternative uses of spaceflight (these included dance, a kiss and floating like geniis) indicated overwhelming resistance to the direct involvement of non-scientists and non-scientific methods in the practice of spaceflight. Nonetheless artists have made substantial inroads into the spacefaring activities. The annual International Astronautical Congress has for some years included a symposium on the role of artists in spacefaring and there is now a technical committee called the International Technical Committee on the Cultural Uses of Space (ITACCUS) that is part of the International Astronautical Federation that provides representation for emerging cultural uses of space technology.

As artists have begun to notice the artistic, poetic and aesthetic potential within the apparent techno-scientific domain of spaceflight and find the means of funding and realising their projects, it can appear that a shift is underway in the disciplinary and cultural make up of the space industry with new kinds of protagonists entering the field and re-determining its terms of reference. As a corollary and sometimes as a central theme, artist-led activities have appeared to have the potential to encourage a bolder conception of who can be involved in spacefaring pursuits by demonstrating through innovative and imaginative activities that the societal periphery is far more capable than often imagined. By showing that non-scientists are capable of comprehending scientific data and technology,[31] artists at the same time demonstrate that the

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[30] The Zero Gravity Arts Consortium was co-founded in 1999 by artists Frank Pietronegro, Laura Knott and Lorelei Lisowsky. Information can be accessed here http://www.pietronigro.com/zgac. Lorelei Lizowsky's comments on her experiences are available on the author's blog at http://www.aconnectiontoaremoteplace.net/?p=157 (Griffin, 2010). See also the publication *Zero Gravity: A Cultural User's Guide* (2005) published by The Arts Catalyst which documents the experiences of the groups flying from Star City.

[31] Examples would be the artist-duo Semiconductor's film *Brilliant Noise* (2006) using data from sun observing satellites. Marko Peljhan's *Project Atol* (1992- ongoing, http://www.projekt-atol.si) in which artists gather and work with scientific data in contexts such as the Arctic where scientific inquiry is the dominant human activity.

ways space agencies cater for a societal periphery through their own outreach and educational programmes is inadequate.

However, such activities led by artists are equally capable of being self-serving to the artists themselves or to specific artist communities. Opening doors to wider public participation does not necessarily generate a critique of the justifications on which space agencies base their claims. The potential for artistic interventions to reframe the terms of reference of space agencies in ways that penetrate the character, culture and structures of the affective spaces of spacefaring, may also be limited. This thesis does however attempt to do this – to reframe the terms of reference of space agencies through art practice – but it does so by setting out to look at ways that artist-led interventions could be used to uncover some inadequacies in the concept of the societal periphery as it forms in relation to space technologies and their organisation. This is a different conception of the role of the artist in relation to space than generally addressed (Griffin, 2012; 2013). For example, a report produced by The Arts Catalyst for the European Space Agency on the *Cultural Utilization of the International Space Station* (2006) addresses only the opportunities for curating high quality artworks as part of Space Station activities and fails to acknowledge that the meaning of culture as it relates to artistic practice can be very narrow.[32] Moreover, that it is the spaces of agency that artistic practice makes available that become the crucial dimension of creative interventions when opportunities for participation are delimited. Such dimensions of the symbiosis between creativity and technology can be obscured as much by the preoccupations of art professionals as they are by preoccupations of technologists. Therefore what is presented in this thesis is a slightly different role for artistic practice in relation to spacefaring than is generally given. The insight provided in this thesis is

[32] Martin Kemp, writing for *Nature* journal notes a similar narrowness to the remit of art/science projects in Wellcome Trust commissions. These were also targeted at the generation of high quality artwork for which: "The trick was to identify a special creative chemistry between high-level participants" (2011, p. 278). But a problem with this conception was that both art and science suffered from an isolation from a wider social domain "...it was easy to agree that mid-twentieth century art and science had become dangerously isolated from each other and from society at large" (p. 278). Shifts in artistic practices produced arguably less isolationist positions making artists' practices relevant to 'relational' (Bourriaud, 1998) or 'connective' (Gablik, 1992) problems in other domains such as science. The 'high quality artwork' was not necessarily the prime criteria of an artistic engagement with 'science' and described an intervention based on the model of artwork and exhibition space, whereas the new spaces opened by science collaboration had the potential to generate new notions of the 'artwork' and art practice, especially in relation to 'society at large' and broader definitions of culture than the notion of 'high culture' often associated with art.

that artistic practices have provided an approximate solution for a problem that is not well defined. But that the mistiness of the problem becomes more visible and better defined through the processes of artistic practices and interventions. In this way creative interventions are recognised through this thesis as diagnostic and as playing a role in a process of realisation. The diagnostic processes held within the creative practice used in the research for this thesis has helped to elucidate incidents of disjuncture in social relations that form as part of the making of space technologies.

A problem remains though in guaging what artistic interventions can achieve and how they are perceived when the institutional interests of space agencies (and other science-led institutions) pervade the interpretation of such interventions.[33] The encouragement given to artists to make work that engages with science merges with agendas of public engagement such that art practices, especially ones that involve obvious forms of participation such as group work, become tools of science communication.[34] Artist's interventions become regarded as instrumental to scientific practices in such situations in part because of confusions over what it is that artists, artworks and interventions do. As Siån Ede comments in the *Public Understanding of Science* journal, "art does not communicate in a straightforward manner... Art often communicates below the level of consciousness. It is not an obvious medium for communication" (2002, p. 67). In some cases (such as Kitsou Dubois' work with the French space agency) being instrumental is a positive attribute that indicates an acknowledged utility of artistic knowledge. In other cases where the new knowledge produced has less clear application

[33] As an example I gave a presentation about a Moon Vehicle workshop at the Global Lunar Conference 2010 in Beijing as part of the education symposium. In the talk I emphasised that the workshop was motivated by a critique of the Moon mission's relation to people in India and that this indicated that such interactions are not purely 'educational' and further that public engagement, or 'outreach', is used for different ends by participants and facilitators. The presentation received a very good response, but only it seemed because it looked like a 'good' public engagement project that promoted the usefulness of space technology to children living in slums. The critique I was offering was lost because the images of children making their own spacecraft could easily be subsumed into the existing agendas of the space agencies. This kind of interpretation of the images of the Moon Vehicle workshops has in part led me to make minimal use of documentary images in the thesis.

[34] For example in the UK through funding schemes such as the Wellcome Trust's Sciart grant schemes (1996-2006) and Arts Awards, also the National Co-ordinating Centre for Public Engagement (NCCPE) which began the Beacons for Public Engagement Initiative in 2008. Arts Council awards have also encouraged 'interdisciplinary' practices (Ferran, 2006).

the value of what is being revealed can be lost.[35] Artist's projects that involve public engagement with science and art/science projects tend to be perceived as supporting the structures they may intend to critique.[36]

iii. Topographies of collective nouns

A problem that permeates spacefaring is the tendency to posit various claims for human collectives such as mankind, nations, societies or even communities of scientists and by so doing a construction of categories of the human is produced. Most ubiquitous is the category of 'general public' which tends to stand in for an anonymous 'other' while the equally anonymous category of 'space agency' assumes a primary role as intercessor between Earth and space. In such ways, relations to outer space and cosmos can become modelled in terms of a relation to and dependency on the space agency. These patterns of notional categories, which in many ways are imagined patterns of social relations, are investigated through this thesis. It is suggested that these notional categories present a problematic assumption of a shared experience and are thereby ineffective in taking account of particularities at more granular levels of human experience. The tendency to subsume the heterogeneity and the particularity of human experiences reinforces the idea of there being a consensus behind the enterprises of spacefaring of shared goals and of a collective knowable humanity.

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[35] The controversy caused by artist Laurie Anderson's residency at NASA is a case in point. Her work critiqued the plans of NASA to return to the Moon and she created an epic poem and performance called 'The End of the Moon' in response to what she found during her residency. NASA ended the residency scheme as a result. Laurie Anderson spoke about her experience at The Roundhouse in London in 2006 as part of the exhibition 'Space Soon: Art and human spaceflight' produced by The Arts Catalyst, which the author attended.

[36] Charting the negotiations of artists and scientists of the convergences of expectations that come to light when collaborations are attempted are subjects of study in themselves. Artists in Labs is an ambitious long-term project in Switzerland, which is supported by extensive ethnographic documentation and critical commentary of the experiences and processes of artist and scientist collaborators (Scott, 2006). Yet the frictions and commonalities that become exposed through such encounters are revealing of supplementary issues. The social anthropologist James Leach uses art/science collaborations to develop a discussion on the notions of reality described through these encounters to illuminate other kinds of divisions and to question how personhood is performed in these interactions (2011; 2012). However, such subtleties can become obviated when the asymmetry of such encounters limits recognition of the cognitive dimension of the artist's intentions. Artist's interventions that broach science and enter the science workplace are vulnerable to co-option, misunderstanding and controversy as documentation from schemes such as Artists in Labs provide evidence for.

The problem with the use of collective nouns to designate types of connections and commonality across large numbers of people is that such categorisations are generally beyond everyday experience and can only be approximately imagined. The idea of imagined communities has been developed by Benedict Anderson (1983) in relation to how the idea of nation is conceptualised and he points to the inherent unknowability of such a large category "It is imagined because the members of even the smallest nation will never know most of their fellow-members, meet them, or even hear of them, yet in the minds of each lives the image of their communion." (1983, p. 6). This acceptance, or glossing over of kinds of togetherness is probed in a different way by Michel de Certeau who pays attention to the differentiation that is subsumed within large descriptive categories in his seminal work *The Practice of Everyday Life* (1984). He notices a widespread problem that "Marginality is today no longer limited to minority groups ... Marginality is becoming universal. A marginal group has now become the silent majority" (1984, p. xvii). By this he means that majorities (or publics) become marginalised when imagined as large, anonymous collectives without clear agency and, moreover, minority groups hold agency over them. It is in asymmetrical situations in which the few can have influence over the many that his study seeks to counter the anonymity given to majority collectives by articulating hidden processes and affect received and acted on within assumed silent majorities. To these hidden effects and processes "users make (*bricolent*) innumerable and infinitesimal transformations of and within the dominant cultural economy in order to adapt it to their own interests and their own rules" (1984, p. xiv italics in original). What de Certeau focuses on is how things are assimilated and the unspectacular resistances that are maintained within everyday life. The difference between these innumerable inflections and assimilations, which he calls "consumption", and the way an idea, language, technology, law, etc. is assumed to operate by its original makers, reveal a "secondary production hidden in the process of its utilization" (1984, p. xiii). If this idea of secondary production is transferred to the silent global publics in need, apparently, of being educated about spacefaring, then what is often taken to be ignorance or indifference from the purview of the space agency can be understood instead as determined choices.[37] His articulation of the grittiness of differentiations within

[37] There is a strong relation in de Certeau's synthesis to Michel Foucault's unpacking of the structural

supposed collectives confounds any bland assumption that a minority activity such as spacefaring is necessarily of benefit to a majority, or indeed that those benefits could in any way be surmised. Instead, what should be gleaned about a category description such as 'global public' is that a largely unknowable secondary form of production is already occurring in what could be thought of as an affective space of space technology utilization.

The proposition that spaceflight references at some level the whole of humanity may hold true in some regards and have its uses, but if the adoption of the concept of a collective humanity is a problematic assertion then what have been the consequences of this? The frequency with which this species-level claim is used by space agencies as taglines to their programmes and also to justify public money being allocated to spaceflight, calls into question on whose terms this claim is made. When the assumed relevance of spaceflight to humanity guides future projects, which generate business for the established economic infrastructures of a space technology industry, the premise of the claim requires a careful unpacking. The historian Dipesh Chakrabarty (2009) takes up the question of the consequences of species-level claims in relation to the planetary experience of climate change. He sees the idea of human collectivity as a pitfall in comprehending or tackling the growing realisation that humans are agents in geological change. He is concerned because the category always subsumes particularities (2009, p. 16). His caution concerns the ability for such a category as species to be experienced and his insight has important implications for the planetary aspirations of spacefaring. He writes:

> Who is the we? We humans never experience ourselves as a species. We can only intellectually comprehend or infer the existence of the human species but never experience it as such. There could be no phenomenology of us as a species. Even if we were to emotionally identify with a word like mankind, we would not know what being a species is, for, in species history, humans are only an instance of the concept species as indeed would be any other life form. But one never experiences being a concept. (Chakrabarty, 2009, p. 15)

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operations of surveillance in *Discipline and Punish* (1977), but de Certeau maintains that his approach, while complementary, moves in the opposite direction to that taken by Foucault, "at once analogous and contrary" (1984, p. xiv). Where Foucault unlocks the hidden operation of technocratic structures imposed on populations by the few, de Certeau focuses on the complementary set of hidden operations used by populations to deflect the effects of technologies of control, "to bring to light the clandestine forms taken by dispersed, tactical, and make-shift creativity of groups or individuals already caught in the nets of discipline" (1984, p. xiv-xv

To add to this distinction made by de Certeau, within the conversations, dialogues and more journalistic exchanges of Foucault, the application of his theoretical analysis of the structures of power to everyday life did occur substantially and in ways very much in sympathy with de Certeau's position.

Chakrabarty proposes here that being human can be experienced, while being humanity cannot – there is no phenomenology of humanity, he writes, meaning no direct experience, and so no guide for the body with which to make judgments on how to act. A phenomenology of experience[38] presents a critical problem in the conceptualisation of spacefaring because the location of a direct experience of space technology is often unclear.[39] Held therefore largely as an imaginary concept by those not directly in contact with the production of space technologies, the particularities of its affect is consequently too easily subsumed and ignored.

This study attempts to counter the ignoring or subsuming of such affect. Approached from the perspective of an artist and through an entrance point of experiential, social and artistic practices, then synthesised using methods of visual analysis, one of the key moves of the thesis is the foregrounding of experience and authorship. The arts and humanities, in particular artistic and creative practices, invest in the terms experience and authorship, and through these terms describe and understand the human as a worldmaking creature. A phenomenon such as spacefaring is, from the perspective of art practice, more readily anchored to perception and

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[38] As developed by thinkers such as Gaston Bachelard in *The Poetics of Space* (1958) and Maurice Merleau Ponty in the *Phenomenology of Perception* (1945).

[39] I unpack the location of an experience of space technology in Chapters 2-4. In Chapter 2 this is in relation to the experiences of those building spacecraft, in Chapter 3 this is done in relation to media about spacefaring and in Chapter 4 in relation to the Moon Vehicle project and the attempts made to search for a compelling experience of space technology. In regard to the location of a direct experience of space technology Michael Sheehan writes of the first satellite Sputnik providing "ontologically a direct experience of outer space" (2007, p. 6). The cultural archaeologist Alice Gorman has made a fascinating intervention in relation to the material culture of space technology, its location and its identity in which she insists on the preservation of satellites in orbit and not in museums because it is only in orbit that a space technology is really a satellite. The oldest object in orbit, she writes, is the Vanguard 1 satellite that was launched on 17th March 1958. Writing in 'The Archaeology of Orbital Space' she comments that when a spacecraft that returns to Earth is put into a museum it becomes a souvenir "In essence, these satellites and other retrieved objects would become souvenirs of a faraway and inaccessible place, something to remember orbit by" (2005a, p. 11). The phenomenology of the experiences of remote control operators of the Mars rovers is excellently delineated in Janet Vertesi's thesis *"Seeing Like a Rover"* (2009).

Phenomenology, as the experience of things in the world is considered an intrinsic part of materials within material culture studies and this link is significant for locating a phenomenology of space technology in which the direct and tangible experience is hard to locate and yet relations between people and space technology seem easily established imaginatively. The archaeologist and anthropologist Christopher Tilley emphasises the dialectic relation between people and things in his introductory chapter to *The Handbook of Material Culture* (2006), and his commentary is embedded in notions of encounter: "the manner in which people think through themselves, and their lives and identities through the medium of different kinds of things" (Tilley, 2006, p. 4). This is a form of analysis drawn to a phenomenological and experiential relation to things. Space agencies invest in the scientific and technical, so not only is the direct experience of space technology difficult to locate, but the culture of science and technology from which this technology is produced resists the phenomenological or aesthetic. At the end of the thesis (Chapter 6) the notion of a 'subaltern aesthetic' is reached and this category can be associated with a suppressed phenomenology in the conceptualisation of spacefaring.

imagination. The human is not an object in the world that can be collectivised, so much as a particular source of a particular version of the world. In the terms of this thesis, space technologies can be claimed as a utility for all humans, for all living things, or for the entire planet, but only in so far as these categories are relative and unknowable, but perhaps graspable at times through certain experiences and certain acts of authorship.

Notions of personhood, sharing and collectivity are richly nuanced in the pathways of the Moon Vehicle interaction described in this thesis. Artist's practices and their associated commentaries produce conceptions of personhood that are emergent and in ongoing negotiations (Leach, 2012). Art historical canons that have emphasised the artist as individual genius have been countered by a number of revisionist accounts such as feminist art histories that have exposed the gendering of categorisations assumed to be universals. Artists themselves have questioned the notion of the artist as individual creative genius by shifting their practices towards collective forms of creativity in which individual contributions become blurred. The writer Paul Carter in his book *Material Thinking* (2004) provides a series of analyses of creative collaborations in which he probes how persons adopt the intentions of those they work with in subtle, empathetic ways, as does Leach (2012). Such shifts in artistic practice also question authorship. Notions of authorship have been reinterpreted through artists' practices, dissolving the singular notion of the artist into more collective forms. Here Nicholas Bourriaud's book *Relational Aesthetics* (1998) and Claire Bishop's retort in *October magazine* (2004) trace a shift towards the co-production of artworks. Similarly, between Suzi Gablik's two books written a decade apart, *Has Modernism Failed* (1984) and *The Renchantment of Art* (1995), there is a sea change from the notion of the artist as individual creator towards the artist as a problem-solving agent in the world. In her view, artists themselves have shifted their practices towards a 'connective aesthetics' (1992) as a resistance to a Eurocentric notion of individuality and in favour of a more subdued, or shared authorship, learnt, she implies, from non-western cultures.[40]

[40] Literature from social anthropology, for instance by Marilyn Strathern (1988), unpacks variations in the cultural construction of personhood that evidence a lack of commonality in notions of personhood and the Eurocentrism attached to the notion of the 'individual'. Strathern developed the notion of the 'dividual' as opposed to 'individual' and also of the 'partible person' to describe practices of iterative giving in Melanesia that render personhood a shared and relational concept (1988). She develops her

iv. Focal points of existing studies and hybridisation

Most often in the studies of spacefaring a focal point is taken which pays heed to certain overlappings but excludes others. Studies that give teleological accounts of the development of space technology by different programmes such as by Brian Harvey's books on space programmes in Asia, the Middle East and South America (2000; Harvey, Smid & Pirard, 2010) or the catalogue of space technology *Jane's Space Systems and Industry* (Bond, 2013, formerly *Jane's Space Directory*) tell the narrative of spacefaring through the chronological production of rockets and spacecraft.[41] These kinds of narratives have a tendency to reify the perspective of the space industry in accounts of spacefaring. The focus on the space industry perspective is deflected somewhat in a study of spacefaring by international relations scholar Michael Sheehan (2007) in which the focus is put not on technology but politics. Sheehan emphasises not the material artefacts but the "consequences" of space programmes. The kinds of consequences Sheehan is concerned with are for the most part to do with political manoeuvring, which although substantial means that his focus remains on states and space agencies and not on others in less agential positions.

Cultural archaeologist Alice Gorman makes a different kind of study of spacefaring. She takes an approach that extends the conceptual and affective space of spacefaring and its consequences through a consideration of the cultural heritage value of space technology (2005a, 2005b, 2007, 2009a, 2009b, 2009c). By focusing on activities at the boundaries of space installations and on space technologies as cultural artifacts, she dislodges more habitual narratives of spacefaring. Using the disciplinary perspective of the cultural archaeologist who reads artifacts to interpret

anthropological studies into discussions of the co-mingling of science and society some years later in *Commons and Borderlands* (2004a) contributing also to the development of support structures for cross-disciplinary work between artists and scientists. Strathern for instance chaired a judging panel to assess applications in the UK in 2003 for a new phase of art/science collaborations (Ferran, 2006). So threads of concern for how the social is constituted can be noticed to be shared across disciplines and usefully brought together in transdisciplinary discussions needed to address interweavings such as those of science and technology in social domains.

[41] IHS, which publishes *Jane's Space Systems and Industry*, also publishes *Jane's Defence Weekly* and is in the business of producing information for and about military products. The presentation of space technology in this influential publication therefore follows that same schema as for military equipment that arguably reinforces non-negotiable purpose of the technology and its unavailability to citizens.

the social dynamic that produced them, Gorman inverts the perspective of the space industry and instead creates a discursive and analytical space for the subalterns of space programmes, such as people living in the vicinities of space installations in parts of Australia, French Guiana and Algeria which she has studied. The work of cultural geographer Peter Redfield (1996, 2000, 2002) is similar in the ways he also reveals subcultures of contestation specifically around launch sites in which the space agency's dominant claim to serve all of humanity forecloses the specific claims of those living nearby to have their own values upheld. Of the asymmetries within the presumed universal benefit of spacefaring, Gorman writes dryly that space exploration, “transcends local interests” (2007, p165). Her research traverses the public spaces of museums and the sites of space installations with some limited forays inside the space agency (Gorman, 2007). What Gorman and Redfield's research provides are rich, multivalent accounts from viewpoints just outside the space agency.

If the multifarious effects of spacefaring in the wider social realm beyond the sites of space technology production are not well accounted for from the perspective of the space industries themselves, neither are the multifarious social effects within space agency organisations. The comprehensive report made by Diane Vaughan (1996) on the causes of the NASA Challenger accident provides a wealth of insight into differentiation within the workforce. She says of her own account that it is unsettling because it accesses the infinitesimal subtlety of decision-making that takes place within the space agency – a workplace culture which becomes misunderstood and undifferentiated from a perspective outside of its organisational frames of reference. Another searching account of experiences within the space agency is Janet Vertesi's thesis about the Mars Rovers and their team of operators at the NASA Jet Propulsion Laboratory *Seeing Like a Rover* (2009). Vertesi describes in detail the bodily and affective connections between technology and technologist showing how Mars becomes seen through symbiotic remote connections. While Vertesi does consider how images of Mars are released into the public domain, her study is distinctly lodged with the NASA operations team and its more intimate connections to Mars.

Vaughan, Vertesi, Gorman and Redfield's studies are important points of departure for this thesis in the value given in each study to the frame of reference of the viewer. However, the focal points taken by all these studies of spacefaring have perhaps inhibited the recognition of important similarities across domains of the affective spaces of space technologies that can appear to be highly separated and distinctively different. Important insights present in studies such as that by Diane Vaughan of the NASA workplace, and also that of Janet Vertusi (2009), remain confined in the impenetrable spaces of high security organisations. Meanwhile studies that take place outside of the space agency tend to reach only to its boundaries. The idea then of there being distinctions between what goes on inside the space agency and what happens beyond, has again a habit of proliferating. In this thesis that confinement is broken as a shared, more obviously hybrid mix of participants from the space industry and elsewhere interact in ways that are sometimes mutually beneficial and transcend organisational boundaries.

The allocation of domains to spacefaring through the language of collective nouns discussed previously has also created problems in recognising the extent of crossings, merging and shared spaces. The social anthropologist of science and technology, Bruno Latour has described the people, landscapes, artefacts, ideologies, politics and discourse that things such as spacefaring in reality consist of as "hybrids" (Latour, 1993, pp. 1-12). Science labs, organised technological production and other seemingly confined or discrete operations are in reality immense entanglements – like the mythical Gordonian Knot that is all but impossible to untie. In his book *We Have Never Been Modern* (1993) Latour uses this analogy to suggest that a feature of "being modern" is assuming that there are such easy separations of organisations from their local surroundings. He says that making such assumptions is like cutting the Gordonian Knot with a knife instead of understanding its complexity by properly untying it. Latour 's book demands that attention is brought back to the interweaving of foregrounds and backgrounds, which have never ceased despite the vocabularies, and architectures of modernity that attempt to clean up the abiding messiness of life.

The consequences of space technologies that crisscross and merge sites of production as well as the everyday spaces of public and intimate lives and livelihoods must consist of such pre-modern interweavings. In facing the interrelations and 'togetherness' of actual technological systems, the theoretical frameworks developed by Bruno Latour provide a model and terminology. In this thesis a similar untying is attempted but using methods and insights drawn from an artistic perspective. From an artistic perspective the dynamics of what is seen and not seen helps to break with habitual ways of thinking about space technology, space programmes or the space industry as segregated, identifiable and confined to production. Instead, the artistic approach has the potential to jolt expectations firstly by taking account of views that include both the expected protagonists of spacefaring as well as unexpected recipients and users of space technology. Secondly through the artistic approach such views can be acknowledged as always partial and always moving or changing rather like a walker experiences the surrounding landscape both revealing and disappearing. Crucially the artistic approach can account for multivalent views available from multiple first-person perspectives. Consequently this thesis has a more diffused or hybridised focal point than many other studies on spacefaring.

Contribution

i. The heuristic of artistic practice

The accountability of spacefaring – whom it is for and how it should be used – presents a quandary because of a scattering of problems not easily recognised. This is where art practice, used as a heuristic to locate a diffused problematic, has an ability to foreground in a visual and experiential way the infinitesimal adjustments that can be made to totalising accounts. In returning to a central question of who it is that spacefaring serves, it is clearer that "who" is not a category that can be accounted for. Instead assumptions have been made about the social benefits of spacefaring that leave out crucial spaces of affect. The thin and apparently negligible spaces of affect in the social and experiential fields that accompany space technologies are expanded on through the text to indicate the shifting, conflicting and merging dynamics of these fields. Affect cannot be summarised, totalised or universalised. In a paper by social scientist and human geographer Nigel Thrift (2004) that addresses the politics of affect, he offers ways in to thinking about the emergent nature of affect as a flow of forces. He presents a number of interpretations of affect including a particularly potent explication by social theorist Brian Massumi, who writes, "Actually existing, structured things live in and through that which escapes them" (Thrift, 2004, p. 63; Massumi, 2002, pp. 35-36). His explication of affect captures the moving through, the lack of containment of affect and moreover the presence within or animation of more obviously static things by such properties of affect. Notably, the article by Thrift finds that practice and in particular, artistic practice can be a means of apprehending and understanding affect, making affect within "the little, the messy and the jerry-rigged" (2004, p. 75) visible and available for critique. As a heuristic, art practices can foreground and locate qualities of experience that are otherwise evanescent.

Creative and artistic practices also foreground the existence of a range of visual qualities. Alongside the production of space technologies goes the production of images of spaceflight, both actual images as drawings, videos and other media, but also imaginary images created by the inferred, if never seen, architectures and events that constitute spacefaring. This theatre of space technologies includes both actual material production and its extension through imaginaries. These are inseparable, just as visual imaginaries are inseparable from the ideologies, aspirations and motivations that drive the material production of space technologies. Furthermore, the dislocation of spacecraft, humans and living things from the Earth suggests and promotes other imaginaries of separation such as the technological from the natural. The image of humans and technology separated from the natural, living world becomes amplified in a theatre of outer space that although distant overcomes this distance by the extreme focus that can be afforded to the activities that take place there. What happens in space is amplified and projected back onto Earth. This property, as Sheehan has noted in his political appraisal of spacefaring has made outer space eminently suitable for politics. What is concerning is that the image and imaginary produced by the theatre of space technology can be understood as amplifying potentially narrow ideologies and projecting these as universals.

It is suggested in this thesis that particularly forceful imaginaries are produced coterminously with actual space technologies as a result of the visual qualities of outer space in which a stark, atmosphere-free form of light impresses on its subjects, such as spacecraft and astronauts, which in turn are set against the black emptiness of space leaving strong imprints on the memory and imagination. Such images and imaginaries influence the way spacefaring is thought about as happening away from the planet and hides the earth-bound nature of spaceflight and its originating motivations. As an artist-led inquiry, the visual in its expansive forms as image, imaginary, performance and experience is used to shed light on whether the visuality of spacefaring is in any way a cause of the inadequate accounts made of the affective space produced along with the production of space technologies.

ii. Proposing an apparatus for seeing this problem

What is offered in the thesis is a way of imagining innumerable relations as co-present within a landscape in transition. To see the affective space of the technologies of spacefaring and to imagine as co-present within the same landscape innumerable relations, assimilations and resistances requires a further move. To use an analogy, a zoetrope consists of separate images that only when spun reveal an action, dance, or comedy. In a similar way glimpses of spacefaring and its affects from different vantage points produce different kinds of images that need to be spun together in the imagination in order to see the whole activity in its fullness. The thesis moves first to present different glimpses and then to suggest a way of imaginatively holding such differences and ambivalences together.

The problem with this move though is that very often spacefaring seems to suggest that whole views and totalities are possible. Notions of universals seem to find a natural association with spacefaring and a similar ambition could become the purpose again of this thesis – to see more of the whole, or to propose a better way of seeing everything. Such an attempt has to be resisted if being content with partiality is more informative than discovering the whole. There is a false hope of the total view perennially associated with space enterprises. Focusing on the small scale and the intimate in some ways guards against this, but even then there is a tendency to wish to extrapolate from the micro to the macro and again construct a totalising solution. In resistance to this way of thinking and as a reminder not be drawn in by the suggestion of spacefaring that an Archimedean viewpoint is somewhere and somehow attainable, Bruno Latour, in resurrecting the ideas of Gabriel Tarde, provides some useful guidance by saying the macro is not necessarily to be found in the micro, "The difficulty is to grasp how the big manages not to emerge out of the small but to foreground some of its features" (Latour, 2001, p. 7). The apparatus for seeing mergings and tensions across an affective realm produced by space technologies developed through this thesis, aims at presenting a 'togetherness' rather than a whole. It does this by using terms such as foregrounding and backgrounding borrowed from the language of art practice and picture making which give suggestions as to how to think about or imagine relations that defy visibilty.

Chapter structure

Chapter 1 traces a defining ambivalence surrounding the purpose of space technologies. The co-operation of scientists during the International Geophysical Year clashes with the competitive nature of Cold War politics complicating the purpose of the first launched satellite in 1957 Sputnik-1. One theme of this ambivalence is the ways that ideologies of unity associated with the first decades of spacefaring simultaneously produced the tendency for various kinds of differentiation, causing moments of disjuncture in the hubris of space travel. Intellectuals such as Hannah Arendt and Romesh Thapar challenge the certainties of the conquest of space. Amidst the scientific, political, military and commercial stakeholders using space technologies for disparate purposes and vying to establish or shape (Sheehan, 2007, p. 5) a particular imaginary for space enterprises, a distinctive Earth-focused, humanitarian space programme emerged in India around the same time as the Apollo Moon landings. This societal space programme appears as a resistant move against the self-interest and elitist shaping of spacefaring emerging from the United States and Soviet uses of space technology. In India, space technology addressed the needs of those most cut off from the new global future posited by spaceflight exposing the shallowness of the claims by other space agencies to be acting for all humanity. By establishing that the Indian space programme represents an intervention into spacefaring imaginaries and is a resistant move distinctively different from other space programmes, the recent launch of the Chandrayaan-1 spacecraft to the Moon by India appears to renege on that critical founding philosophy. The chapter concludes with the proposition that Chandrayaan marks a moment of disjuncture within a critical intervention that had originally sought to give a more inclusive, more everyday and fuller account of for whom spacefaring was for. As such the launch presents a fault line through which the questions of who spacefaring serves and what it is for can be posed again.

In **Chapter 2** the re-examination of the purpose of spacefaring begins with a three-part study of the spacecraft Chandrayaan. This is called here a 'technography' and Chapters 2-4 consider Chandrayaan from three distinct viewpoints. The first viewpoint, which is the focus of this chapter, is that of the scientists, engineers and technicians of the space agency in charge of the spacecraft's construction. This general grouping is here termed the 'scientist-makers'. This chapter uncovers what the spacecraft mission is for from the perspective of the scientist-makers who construct the spacecraft as a scientific instrument to answer research questions that have been arrived at through a process of discussion and consensus-building largely within the scientific community. A key methodological concern is introduced here whereby the spacecraft is considered in terms of how it is experienced. This becomes a way of accessing the vantage point of individuals concerned and the variety of ways the spacecraft is experienced within the space agency itself. Theoretical perspectives from technology and material culture studies help indicate the biographical comingling of technology and workforce.

Chapter 3 is the second part of the technography in which the defining of the spacecraft is examined from the viewpoint of the Indian state. This is done by considering the public representation of Chandrayaan, which is noted proceeds mainly from a narrow set of official sources. The Indian space agency ISRO is a government department so any publication media emanating from ISRO can be considered to be a reflection in some way of a state sanctioned imaginary of the spacecraft. In this section it becomes clear that a very different set of criteria and definitions are foregrounded by the state than by the scientist-makers, although there are also many kinds of correspondences indicating a merging of and interchangeability of viewpoints. From this vantage point the spacecraft is used as a state apparatus symbolising power, prestige and an attempt to define the status of the Indian nation in the world. The transformations of the spacecraft are contextualised through the concept of state fetishisation as used by Itty Abraham (1999) in his comparable study of nuclear technology. What this connection to nuclear technology also makes clear is that the origins of the plans for the Chandrayaan spacecraft starting around 1999 coincide with the testing of nuclear bombs. Furthermore, that the spectacle of the nuclear explosion can be linked to the spectacle of the launch explosions of the indigenously engineered PSLV rocket. By looking at the visual iconography of space technology presented in the Bengaluru Space Gallery, inaugurated in 1999, Chandrayaan can be contextualised as a demonstration vehicle for the PSLV rocket. Significantly for the argument of the thesis this links to the dissemination of political ideologies via a visual imaginary of the fiery explosion. The incommensurability of these state informed meanings of space technologies with the meanings held by the scientist-makers are highlighted and evidenced. However, it is also noticed that individuals frequently traverse domains such as from state spokesperson to space engineer. This suggests that political ideologies are only haphazardly attached to the iconic materiality of space technologies through contingent social processes.

In **Chapter 4** a very different set of experiences, imaginaries, uses and agencies become apparent as a project called Moon Vehicle, which was led by the author, is presented in the third part of the technography of Chandrayaan. Through this example the method by which art practice exposes a visual layering to the production of space technologies is made apparent. The project involved many events, workshops and other activities that brought together ISRO employees working on Chandrayaan with children from local neighbourhoods, and with artists and design students. Evident during this process are the ways that the imaginary of the spacecraft was negotiated, shared, contested and infiltrated in ways not anticipated in the state-authored version of Chandrayaan's purpose presented in the previous chapter. What is also made apparent in this chapter is that the Moon Vehicle project proceeded from a set of anxieties that the launch of the spacecraft brought to the surface. It is proposed that these anxieties were related to an underlying sensitivity to implications of the space mission that could be sensed but were difficult to grasp fully. This is supported through theoretical perspectives on cultural technologies that foreground problems with the reception of large-scale technologies in everyday life including hidden tactics of control. The conclusions of these studies point to the significance of creative interventions where delimited spaces for interpretive flexibility of technology are available. This substantiates the creative intervention of Moon Vehicle. But it is argued that in the qualities of the first-person perspective that the Moon Vehicle project drew attention is a key to the motivations behind the creative intervention. The artistic approach adopted in the project is analogous to comparative uses of literacy and writing as practices of resistance and produces a demonstration of heterogeneous viewpoints and spaces of agency. The claim is made here that what is missed in accounts of spacefaring is the valorising of the first-person viewpoint, a perspective from which myriad inflections of authorship adjust the purpose and affect of space technologies.

Chapter 5 reflects on the way a comparative problem has been addressed in subaltern studies whereby missed voices have been reinstated into history. Using methodological insights from subaltern studies a genealogy to the problem identified in this thesis is revealed and also a way of structuring the problem. In this chapter the use of an optical metaphor by subaltern historians to draw attention to missed voices in history has a similarity to the focus on seeing established through the artist-led project Moon Vehicle. Insights from the methodologies of subaltern studies scholars are then used to examine a formational episode in the Indian space programme called the Satellite Instructional Television Experiment (SITE). This project, that established the idea of a societal space programme for the people of India, was claimed as a success but in a number of ways missed the opportunity of adequately including its audiences. As a comparative example the documentation of SITE substantiates how creative and customised use of the satellite technology were left out of official reports. The example also reveals that a precedent for the artist-led Moon Vehicle collaboration with ISRO existed as an art and design college collaborated with ISRO during the SITE project in the 1970s. The methodological and reflective style of the historians of the Subaltern Studies Group draws attention to the processes by which such precedents become lost and forgotten. It also provides a structuring of the problem addressed in the thesis, as the creative intervention of the Moon Vehicle project can be understood in terms of subalternism. The chapter concludes by asking 'Can the subaltern be seen?' A theoretical model proposed by subaltern historian Dipesh Chakrabarty is presented that provides a way to reinstate the missed component of the subaltern viewpoint and gives substantial agency to the prospects of interventionist strategies.

Chapter 6 directs attention to what it is that the artistic approach adopted offers to the interpretation of space technology. The aesthetic or artistic approach has been noticed in other studies to be a significant space for intervention when participation in large technological systems is inhibited. Aspects of the artistic and transdisciplinary approach adopted are unpacked in this chapter to reflect on the interweaving of visuality and imaginary. It is proposed that this approach allows the technography to be translated into a 'technographic picture'. This move gives latitude for the technographic picture to be interpreted through its figuration as an imaginary in addition to other means. The proposition offers a new transdisciplinary modality for the interpretation of space technology that has transferablility and forms a key original contribution of the thesis.

Terminology

Within the thesis some conventions have been adopted in the use of language and terminology. The terms **spacefaring** and **space technologies** are used throughout the thesis almost interchangeably. Space technologies though refer more specifically to the material production of technologies and this is often used in the text to make links with discourse on technology. Spacefaring refers more generally to the activities and journeys of spacecraft. In the thesis they are used interchangeably while retaining their separate leaning in subtle ways.

Likewise the terms **spacecraft** and **satellite** are used as interchangeable terms, although a satellite denotes a state of orbiting and spacecraft denotes the object, not necessarily in orbit. The term spacecraft was more often used by space scientists in conversations during the research process and may be more prevalent in relation to interplanetary missions. The term satellite is more associated with Earth-orbiting communications satellites. The distinctions are not the concern of this thesis, but the term spacecraft is used predominantly.

Space exploration is used sometimes in the thesis however in the space industry the term exploration has a specific meaning referring to human spaceflight and interplanetary missions. Space exploration has been used as a term differentiated from **space science** and there is some controversy within the industry about the merits of each. For example, there is contention within space agencies from those who think space exploration is populist and diverts funds from the less populist pursuits of space scientists. To avoid reference to that contentious debate within space agencies, the term space exploration is mostly avoided and again this debate is not a specific concern of the thesis.

The term **scientist** is used often in the thesis in a generalised way, whereas the actual roles that scientists would describe themselves as having would be much more specific. There are planetary scientists, experimental scientists, space scientists, astronomers, astrophysicists, cosmologists, etc. and many ways that individual scientists describe their particular specialism and affiliations. The range of titles for scientists and engineers associated with space technology production is specifically noted in Chapter 2 where the use of the term 'scientist-maker' is introduced. This metonym is used as a substitute in the thesis to account for a range of practices including technical, engineering, science and management that occur within the organisation of the space agency and are in reality highly differentiated, specialised and interdisciplinary. So that an acknowledgement of that richness is not lost, the use of the metonym 'scientist-maker' is used to avoid the too general term of scientist.

Finally, there are many different kinds of satellite. In this thesis the focus is mainly on a spacecraft sent to the Moon with scientific instruments. Science satellites are only one kind of satellite. The majority of satellites in Earth orbit are communications satellites redirecting many kinds of data across the globe including television, banking transactions and mobile phone communications. Another category of satellites is military, then there are satellites used for navigation (such as GPS) and there are weather satellites. The distinctions between these kinds of satellite are not covered in this thesis though different types are referred to including remote sensing satellites, which survey and take images of ground terrain for many kinds of geophysical applications. There are many ways that the purposes of satellites can be ambivalent, for instance an Earth-imaging satellite can also be used for surveillance. Countries launching satellites are required to make information about the purpose of satellites public, but there are ways to gloss over details. The kinds of ambivalence of space technologies highlighted in this thesis, while they focus on a space science spacecraft have implications for these other types of satellites also.

Of non-technical terminologies used in this thesis is the term **imaginary**. Imaginary refers here not to fantastical or falsified imaginings of things that would never be real. It registers the immaterial dimensions of technological production. Imaginaries can be thought of as apparently mutual understandings that constitute realities (Sheehan, 2007, p. 5) for which the word 'associations' could also be used (Gorman, 2005b, p. 88).

Michael Punt has used the term imaginary specifically in relation to technologies. He uses the term "technological imaginary" (Punt, 2000) to refer to how the technical apparatus of the cinematograph was mutually understood. There could be many technological imaginaries and his work shows how it is the imaginaries, rather than the material technology, that shifts during the emergence of cinema, and which account for the trajectory of the technological inventions that comprise cinema, to gel into what is the currently accepted and workable form of film screenings within cinemas. Imaginaries, he suggested, can therefore count as determinants of technological use. The work of Punt in relation to early cinema could be applied in some respects to early spacefaring. Especially in the tensions during the initial formation of the technology in which the pulls for a spacefaring imaginary encompassing the utopian ideals of scientific cooperation pulled against an imaginary in which spacefaring was a dystopian theatre for the enactment of Cold War politics.

Benedict Anderson uses the notion of imaginaries to suggest how the binding of people into abstract structures such as nations, can happen because although 'nation' can never be seen in its entirety, from a partial sense of what nation is and means, the whole is imagined. Imaginaries in this case are taken as commonly held assumptions of a whole that cannot ever been seen in its entirety, "It is imagined because the members of even the smallest nation will never know most of their fellow-members, meet them, or even hear of them, yet in the minds of each lives the image of their communion." (Anderson, 1983, p. 6). Such overarching imaginaries, if they are at work in defining entities such as nations, must also be at work in defining imaginaries that pertain to the partially seen or known infrastructures of space technology.

The term imaginary is used in this thesis to denote notions felt to be mutually held. However, the notion of imaginaries is also used in this thesis in another way to denote a space of particularisation. As well as the generalised imaginary that Anderson suggests exists for the idea of nation to hold such sway, and the "mutually held" notion of the technological imaginary put forward by Punt, are the partially shared but more granular imaginaries held within acts of authorship. Actions foregrounded in this thesis of drawing, performing and writing are forms of authorship, which provide evidence for the particularisation of imaginaries and a locus for the distinct differences that exist between first-person imaginaries. An emphasis is put in this thesis on the granularity of the mutually held imaginary to give a distinctive place for the workings of imaginaries from the viewpoint of the first-person – the author. The advantage of working from the perspective of an artist is that imaginaries of particular persons and collectives can be located within material productions such as drawing images. Drawings hold clues to mutually held imaginaries, but an authored work is primarily a culturally significant assertion of a particular imaginary and imagination held by a person. So the use of the term imaginary differs slightly from that of Punt or Anderson in that it tries to encompass an account of real experiences and agencies as originating determinants of technological form. In keeping the argument of the thesis and its function within parameters that retain the possibility of application in real-world situations, this inquiry determines its position in relation to accessible experiences of the real-world. It locates through artistic practice a missed interface, made evident in practices such as drawing, where imaginaries interweave technologies.

The concept of **imagination** as it is used in this thesis relates to manifestations within creative production and as such has an empathy with phenomenology. Maurice Merleau-Ponty, whose seminal work *Phenomenology of Perception* develops the concept of phenomenology from Husserl (Merleau-Ponty, 1945, Preface) and established a philosophy of perception rooted in experience writes, "To perceive oneself as imagining is to set up a certain kind of relation with the absent thing." (Edie, 1964, p. 60). Imagination, described in this way by Merleau-Ponty, can be understood as pivotal in any study of space technology for which the absent object is an inherent part of the technological infrastructure.

Finally, the phrase **first-person viewpoint** has a pivotal role throughout the thesis. The phrase is used to draw attention to a space in which heterogeneous agencies are performed or articulated. It is used to theorise intimate interpretive spaces obscured by the intimidating architectures of space technology. The phrase 'first-person' is borrowed from Geetha Narayanan (Founder/Director of Srishti School of Art, Design and Technology) who used the phrase in her research into learning styles of children to describe the primary role of first-person experiential learning for children up to the middle-school age.[42] She herself had adapted the phrase from the concept of "first-person consciousness" used in relation to cognition and perception by Varela

[42] My use of the term in this thesis stems from hearing the phrase used by Geetha Narayana (who initiated the Moon Vehicle project which the author led) in a presentation in 2012 for the Building Learning Communities Conference in Boston in which she overlaid the notion of first-person, second-person and third-person consciousness (derived from Varela and Shear) to indicate that children up to middle school age (around 12 years old) used first-person experiences to learn about the world. Her point was that experiential learning is important for younger children, after this age children begin to learn through second and third person perspectives, in other words learning happens mostly through the texts (and experiences) of others. When I heard this use of first-person experience it struck me that this was the inversion of viewpoint I needed to dislodge the overview imaginary that seemed woven into the fabric of spacefaring and to be blocking critique or dissent at more granular levels. The notion of 'first-person' seemed immediately grounding and to resist the assumption projected so often by space agencies of a consensual agreement in space programmes, an assumption propounded by the overview image of the 'Whole Earth'. First-person viewpoint is interesting also in relation to many of the Moon Vehicle workshops that involved children around twelve years old and a perceived correspondence between the ways of knowing of children and artists (see Mistry, 2009).

and Shear (1999),[43] The notion of 'first-person' is used in the thesis as a device to forestall the assumption of consensus that has come to inhabit spacefaring enterprises. First-person viewpoint does not necessarily atomise humanity down to the individual, but allows for viewpoint to take whatever form and quality it may – culturally or temporally. At the centre of the thesis the convergences, changeability and sheer inacessibility of the first-person viewpoint is considered through an analysis of a drawing. This forms a notional benchmark to the kinds of oversights that become normalised into the operations of the space industry.

Transferability

The thesis provides a new interpretation of the significance of the Indian space programme and it provides an extensive analysis of the Chandrayaan spacecraft, but it is not a study of space agencies *per se*. Rather, it is a study of the appearance and use of spaces of agency. The thesis steers a course that provides frameworks for re-thinking the wider impacts of spaceflight, while also providing through its argument, a framework for thinking through other kinds of complex social-technological-environmental problems, not necessarily related to space.

Spaceflight provides an indispensable *example* of how humans have thought about themselves at the level of species and in relation to the planet. In the flaws to the generalised claim to be

[43] The paper 'First-Person Methodologies: What, Why, How?' begins with the explanation, "By first-person events we mean the lived *experience* associated with cognitive and mental events." (Varela and Shear, 1999, p. 1, italics in original). Their intervention is to make allowance for the subjective within a discipline defined primarily by the need for objective data: "One central purpose of this first-person methodologies Special Issue is, precisely, to survey some major current approaches that attempt to provide the basis for a science of consciousness which includes first-person, subjective experience as an explicit and active component" (p. 2). So what appears as a narrow use of the term in relation to humanities approaches to experience is less so in relation to the intervention in the scientific field that Varela and Shear are concerned with. They claim their study is stripped of cultural associations in an attempt to understand a shared human attribute. As such it has shortcomings which Varela and Shear indicate. In their introductory article to the *Special Issue of the Journal of Consciousness Studies* is a section on Buddhist teaching of which they state: "We can completely put aside in this Special Issue the motivation and values underlying such Buddhist practice and traditions." (1999, p. 6). They describe their approach as "pragmatic" but admit its shortcomings are many, writing, "Our pragmatic orientation is likely to leave some readers feeling cold" (p. 13) especially as a scientific study of experience cannot factor out: "the experiential and social dimension in science [that] is often hidden, but never entirely absent." (p. 13). They offer a method with shortcomings – the values brought to bear in interpretation the "hermeneutic objection" (p. 13)) – that may nonetheless have use. However, in this thesis no connection is made with the Varela and Shear's formulation, although my use of the term derives in some sense from the focus brought by their inquiry.

acting 'for all mankind' on which the space industry can readily be called to account, lies a cautionary tale or, more hopefully, an example of a failure from which to learn in the face of other large-scale problems and systems, such as climate change, that require a large-scale response with flexible, informed interpretation from grassroots perspectives. The thesis suggests that this is better achieved through interlinking the first-person experiential viewpoint, as demonstrated through creative arts practices, into concepts of collectives. The apparatus for seeing space technology that is proposed has applicability and transferability across other kinds of affective spaces.

Chapter 1

The structural ambivalence of space technologies

It will be argued in this chapter that there are many kinds of pervasive ambivalence that make space technology hard to see clearly at a literal and a metaphorical level. At a literal level much of the technology is out of sight either in outer space or within secure bases. At a metaphorical level space technologies can be difficult to see clearly (understand) in part because their uses and purposes require a degree of expert knowledge in science and technology, in part because there are political motivations behind the production of space technologies that complicate the scientific and technological rationales. This literal and metaphorical difficulty in seeing is key to understanding the limited ability of space technologies to fulfil the desire to benefit all and is given the term in this chapter 'structural ambivalence'. Here structural ambivalence means contradictions (or ambivalences) that become inherent characteristics (or structural). When characteristics become structural they become invisible, as if crystallised into the technological form and when this happens an ability to critique or negotiate such characteristics is lost. To call space technologies structurally ambivalent is a reminder that this type of technology is far better understood as variably constituted, inherently uncertain and open to interpretation.[44]

[44] An important reference here is the term "structural violence" used by the peace studies scholar Johan Galtung in his thinking about imperialism, development and peace. The key text that explores 'structural violence' is *Violence, Peace, and Peace Research* (1969) and here he shows how covert forms of violence or imperialism are hidden within technologies in ways that are difficult to grasp. His point is that technology that can appear to be benign transports less benign cognitive expectations that are structured into the ways such technologies can and cannot be used. His concern is for the spread of western technologies into developing countries during his times and the lack of recognition of the violence that can be done by the inflexible and invisible cognitive structuring that accompanies the seemingly benign adoption of new technologies globally. His arguments will be related more closely to the present study in Chapter 5.

Nonetheless space programmes, in order to justify their budgets are invariably presented publically as having such singularities of purpose together with unifying intentions.

In this chapter examples will be considered which emerged in the early years of spacefaring and it is argued that in these formational programmes, with their accompanying imaginaries and technological breakthroughs, there are indicators of a structural ambivalence that continues to pervade space technology. In the first part of the chapter some formational structures emerging in the early days of spacefaring are considered in relation to some criticisms, objections and resistances emerging at the same time. From this it is possible to see how these contradictory formational episodes lead to a structural ambivalence. In the second part of the chapter the provocation that these hovering uncertainties provide for critical intervention is explored.

One defining characteristic of space technology is a double identity in which a neutral, objective pursuit, for instance of scientific measuring of the atmosphere, is purloined for political or military ends such as surveillance.[45] 'Dual-use' is a term given to technologies such as nuclear energy that can be used for the peaceful purpose of providing energy, but the same knowledge can also be used for the military purpose of making nuclear warheads. While the transfer from one to the other is not in reality as straightforward as the term implies,[46] nonetheless, the suggestion of dual-use has had huge political strength as a feasible idea capable of realistic threats. Anxieties caused by the perceived intentions of nations developing nuclear technology has led to treaties, bans and embargoes between nations seeking ways to inhibit the nuclear

[45] It is relatively easy for satellite launches to be described in vague or ambivalent terms. The monthly *Spacewarn Bulletin* (Grayzek, 2011), which was published by NASA in its capacity as a World Data Centre up till July 2011, provided only minimal details of satellite launches and decays based on information received from launch agencies. The United Nations Office of Outer Space Affairs also maintains an online registry of launches and decays of satellites (UNOOSA, 2013). The inadequacies of monitoring processes are highlighted by independent interventions. *Jonathan's Space Report* (McDowell, 2013) is one example of an independent scientist who meticulously cross-references official launch announcements and produces his own e-newsletter. Another is the Union of Concerned Scientists (2013) which produces a Satellite Database that substantially helps the process of monitoring, comparing and analysing the orbital environment by producing an Excel datasheet instead of the more difficult to search online indexes.

[46] Itty Abraham makes this point in his study of the Indian atomic bomb (Abraham, 1999, pp. 143-4 and p. 148). Here Abraham looks at the arguments of Vikram Sarabhai, who besides leading the space programme became the Chairman of the Atomic Energy Commission. Sarabhai argued against the detonation of a nuclear bomb on the grounds of this being a "paper tiger" saying that even if India had the ability to make and explode a bomb, it did not have the infrastructure in place that would constitute a full nuclear deterrent system (Shah, 2007, p. 165, the quote is referenced to a transcript held in the Dr Vikram Sarabhai Archives, Nehru Foundation for Development, Ahmedabad of a speech by Sarabhai given in 1966 at a press conference).

capability of other nations,[47] with the war in Iraq that began in 2003 one of the most devastating examples of this. Likewise space technology has had a spectrum of uses that include a high percentage of military use, which carefully circumvent the agreement within the Outer Space Treaty (1967) to use space only for peaceful purposes (Sheehan, 2007, pp. 10-13). When in 1957 the Soviet Sputnik went into orbit as part of the scientific activities of the International Geophysical Year, it was understood by the US administration as a veiled threat that proved the Soviets had the rocket power that could potentially be used to send a warhead into the necessary suborbital trajectory towards the United States – an Intercontinental Ballistic Missile or ICBM (National Security Council, 1955). That space technology has potential for 'dual-use' is evident also in the embargoes made by the United States on India's development of a cryogenic engine for its planned Geosynchronous Satellite Launch Vehicle. At that time, in 1992, Russia was prevented from supplying cryogenic technology to India by United States administration (McGirk, 1992; Raj, 2010; The Hindu, 2013).[48] The substantive idea of 'dual-use' is an important category of the structural ambivalence of space technology, however, the double identity of space technology permeates far more deeply than this political-military category of 'dual-use'. The double identity, or multiple identity, or pervasive ambivalence of space technology is a more nuanced, more evasive and ultimately has a greater range of determining effects than the phrase and meaning of the term 'dual-use' encompasses.

An aspect of this ambivalence or ambiguity derives from a condition in which space technology articulates a dialectic position between Earth and Space. The international relations scholar Michael Sheehan has written about the politics of spacefaring in order to bring the interplay between space-based technologies and Earth-bound political consequences into the sphere of international relations discourse. He points to the significance of the first satellite Sputnik reaching orbit in October 1957 as marking a moment when, “space became an ontological

[47] In terms of the nuclear issue, the Treaty on the Non-Proliferation of Nuclear Weapons (1970, commonly called the Non-Proliferation Treaty or NPT) and the Comprehensive Nuclear-Test-Ban Treaty (1996, commonly called the CTBT) represent attempts to manage the ambiguities of developing nuclear arms as deterrents. For discussions in relation to the South Asian context see Abraham (2009).
[48] The embargoes set by the United States to block Indian technologists from acquiring cryogenic technology from Russia delayed India's ability to develop this type of rocket engine. Recent reports suggest that the development was scuppered in other ways also with the ISRO spy scandal of the 1990's now being linked to the removal of key scientists working on the cryogenic engine (The Hindu, 2013).

reality directly experienced by mankind" (Sheehan, 2007, p. 6). The spacecraft touches space in a new way, establishing an experience different from that of looking at the night sky or imagining gods or spacecraft traversing interplanetary space and yet at the same time also describing those preceding imaginaries.

Space technology describes a threshold already explored through beliefs, mythologies and fictions.[49] Yet a pervasive dimension to the ambivalence of space technology is that it is emblematic of a rational science and technology utterly antithetical to such originations. The political psychologist and cultural theorist Ashis Nandy (1988) writes of Kennedy's 1962 speech announcing the Moon missions as heralding science as a new reason of state and the moment, he argues, when technology became synonymous with science.[50] Science, when understood as the pursuit of objective, value-free and rational explanation, seemingly disenchants the heavens, as the material technologies of space flight become a reality. Yet in spacefaring the line between hard science and imaginaries is far from clear. The cultural repositories that space technology appears to negate such as the spacescapes of gods or the fantasies of fiction writers and filmmakers are found incorporated into its fabric. The writing of science fiction by space technologists such as Arthur C. Clarke and Carl Sagan[51] provide some access to the ambivalent

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[49] Reference can be made here for instance to Hindu, Greek and Roman mythology which is replete with various kinds of air and space travel. Ravana, who steals (or in some versions rescues) Sita from Ram in the Mahabharata, has a plane and all Hindu gods have a personal flying vehicle, or *vaahana*. Ganesh's vehicle is a mouse. In one story, Ganesh fell off his mouse (possibly from overeating!) and the Moon laughed at him. Furious, Ganesh cursed the Moon making it disappear, softening the curse later so instead the Moon waxed and waned. For a discussion of the relation of science to fictions in Indian cinema see Raminder Kaur's chapter in the Routledge Handbook of Indian Cinema (2013b). Re-evaluating the supposed lack of science fiction coming from the subcontinent, Kaur develops an approach to "speculative fiction *masala*" that acknowledges the enabling scientific apparatus of cinema to portray the fantastical and the plethora of science inspired fictional films – including time travel, space travel, aliens and invisibility – produced in India. For further discussions of science fiction and film see Punt, Blassnigg and Surman (2006) for ideologies conveyed through science fiction films. For a discussion of how science fiction stories and ilustrations led to space technology being taken seriously by politicians and scienctists see Ron Miller 'Space Flight and Popular Imagination (Dick, 2007). For a discussion of American pioneer narratives and other myths or imaginaries of progress influencing spacefaring see Linda Billings essay 'Overview: Ideology, advocacy, and spaceflight - evolution of a cultural narrative' (Dick, 2007).

[50] Nandy is writing about the alliance between science and state that developed in India after Independence and under Nehru's leadership as part of a drive to modernise the country, The essay, which appears as the introduction to the book *Science, Hegemony and Violence: A requiem for modernity* (1988), shows the humanitarian cost of large-scale technological projects implimented in the name of modernity, progress, development and science (such as dams, atomic energy and the adoption of agricultural fertilizers and pesticides).

[51] Arthur C. Clarke wrote technical texts and essays as well as a prolific number of science fiction books. Carl Sagan who is best known as the writer and presenter of the television series Cosmos (1980) was also

oscillation between spacefaring fiction and fact. The naming of missions such as Chandrayaan, Apollo and Chang'e after figures from mythology could be read as another marker of the slippage between the putative rationality and irrationality of actual space technology and its imaginary avatars.[52] The transferences between fiction and reality that can be traced in the construction of space technology are revealing of the ambivalent origins of spacefaring rationales. The confusion over the relation of this technology to fictions is exacerbated when imaginaries are both exploited to gain popular support for space programmes (for instance in the Founding Father's narrative of progress) and disavowed to justify expenditure (the rationality narrative of science and technology).[53]

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a space scientist working on a number of projects including the Voyager spacecraft. He wrote the fiction book Contact (1985), which was also made into a film (1997), about contact being made with aliens using an antenna dish. The book coincided with the establishment of the SETI experiment – the Search for Extra-Terretrial Life.

[52] Chandrayaan is named after Chandra the Indian god of the Moon. Apollo is a Roman and Greek god and Chang'e is a princess in Chinese mythology who swallowed a pill of immortality and floated (or fled) to the Moon where her only companion was a jade rabit (the name given to China's recent linar rover).

[53] Efforts made in the early realisation of spaceflight to transform the fantastical idea of space travel to a plausible and practical possibility are telling of the careful negotiation and interdependency of space technology with science fiction. In his book *The Red Rocket's Glare: Spaceflight and the Soviet Imagination*, 1857-1957 (2010) Asif Siddiqi traces the writing by the Soviet technologist Konstantin Tsiolkovskii of a technical manual of spaceflight in which Tsiolkovskii proves the technical possibility of spaceflight. Siddiqi indicates how Jules Verne's novel *From the Earth to the Moon* (1865) turned what had been hitherto thought of as 'astronomy' into 'space travel' (p. 19). Tsiolkovskii's writing became more widely known through Perel'man, a science fiction and science writer who used Tsiolkovskii's treatise to write plausibly about space travel, "giving" Siddiqi says, "the idea of cosmic travel a sheen of respectability on a par with any other established and professionalized science such as mathematics or astronomy" (p. 39).

This shift to the plausible and respectable was key to the realisation of spaceflight and can be noticed also in the efforts of rocketeer Werner Von Braun to convince the US administration under Eisenhower to pursue a space programme. Here the merging of fiction with reality was thoroughly ambivalent. Von Braun worked with Walt Disney to make several programmes about spaceflight in the mid-ninteen fifties. For Von Braun the purpose was to make spaceflight credible while Disney wanted to promote the fantasy of spaceflight for his new theme park enterprise Disney World for which he needed content for the future-themed area Tomorrowland. For this the slippage between documentary and animation used in the television programmes cleverly maintained both the allure of fantasy and the 'nuts and bolts' appeal of technology. At the same time the director/writer/producer of the series, Ward Kimball, called up scientist friends to gather the most up to the minute information on rocketry know-how, exploiting to some extent the glamour of his Hollywood job (Kimball and Smith, 1977). The TV programmes criss-cross the line between hard science and action adventure beginning in a documentary style in the studio where Disney, Von Braun and Ward Kimball talk directly and informally to the viewer about spaceflight. Then Kimball casually asks an animator to make a sketch of a rocket that magically comes to life as the action moves into an animated world of daredevil astronauts visiting the Moon, Mars and setting up space colonies. This literal translation of idea to seeming reality, Kimball shrugs off in interviews as a device to make the subject matter more watchable, but its effects are to subtly make the far-fetched idea of spaceflight appear plausible, a *fait accomplis.* An article written by Kimball's interviewer David Smith '*They're following our script: Walt Disney's Trip to Tomorrowland*' (1978) adds to speculation around the links between actual events and the work of the visual designers of the Disney production studio. Ward Kimball's interview with David Smith is also a source of an anecdote in which Kimball says that President Eisenhower called Disney and requested a copy of the *Man in the Moon* programme, which was apparently screened to policy-makers in the Pentagon. NASA historian Michael

If space technology is a figuration of a social quest to understand what Earth and Space are and mean, then space technology has to be understood as a manifestation of imaginaries adapted and reconfigured through the contingencies of materials. Space technologies are dependent both on imaginaries and technological capability. Their form and use are a synthesis of the projected ideas of what space technologies should be (imaginaries) and the available capability to work with the materials and physics needed to construct space vehicles (technology). As a material, space artefacts are full of information about our times, of aspirations, capabilities and about us. Material culture is an academic field through which space artefacts have only recently begun to be studied, most notably by the archaeologist Alice Gorman (2005a; 2005b; 2007; 2009a; 2009b) and the media studies theorist Lisa Parks (2001; 2005; 2012). The study of material culture is a way of accessing aspects of culture through understanding the forces through which artefacts come into being and the ways they are then used (Tilley, 2006, Introduction). The form that space technologies take is not the only figuration that could have been arrived at but what is manifested then describes, or provides evidence for, a range of relations, capabilities and decisions. A great deal of power has been attached to the manifestation of space technologies, a power linked to the level of difficulty in achieving spaceflight which has held immense imaginative and political sway. This has a tendency to occlude both the notion of alternatives and the notion that the genealogy of spaceflight lies in preceding imaginaries of a non-technoscientific nature. Space technologies can be thought of as fragile constructions at a dialectic position marking the negotiation of an unknown at the edges of the Earth through both imaginaries and technologies.

What happened in the early days of spaceflight, Sheehan notes, had the effect of "shaping" what it is that space was thought to be for, and it is particularly the Cold War politics of the 1950's and 60's that he says, "cannot be overestimated" (2007, p. 4) as a formational influence:

> By firmly establishing a specific perception of outer space, a dominant narrative helps to shape a particular reality. We perceive outer space in a particular way, as a particular

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Wright (1993) considers this unconfirmed and it is not clear from the interview whether this happened after the launch of Sputnik in 1957 or between the first airing of the programme in March 1955 and the announcement by President Eisenhower in July 1955 of the intention to pursue an Earth satellite programme.

> kind of realm, in which certain types of activity are possible, even expected, while others are frowned upon or specifically forbidden. (Sheehan, 2007, p. 5)

In an analysis of early cinema that helps to give latitude to the many processes by which new technologies in general can find a form and purpose, Michael Punt (2000) provides insights into the ways such "shaping" can be accounted for. His analysis of *Early Cinema and the Technological Imaginary* moves away from the idea of inventors inventing cinema to a much more nuanced approach that takes account of an environment of devices, inventors, publics, contingent events and many kinds of interpretations from which the form of cinema eventually emerged. He uses the term "mutual intelligibility" as a framework for understanding how the eventual form of cinema came about, pointing out that it was not at all clear from the early devices invented for projection that cinemas would be the eventual housing for these new apparatuses. Significantly this framework of "mutual intelligibility" included not only inventors but also publics as users who equally played a determining role in the development of cinema. Similarly, space technologies have early histories in which the decisions of state policy-makers, technologists, press and television mediators as well as wider publics comingle as the many kinds of social processes from which space technologies also emerge. Unlike cinema though, where audiences take a seat and buy a ticket, the role played by publics in the formation of space technologies is less easily evidenced, despite the positioning of spacefaring as being for publics and for humanity. Kennedy's speech, for instance, announcing the Moon missions in 1962 was directed at the United States public and positioned for the benefit of the nation and for "all people". However, in the shaping of space technology that Sheehan describes, what it is that both spacefaring and outer space are thought to be and what is "frowned on or specifically forbidden" in space can be found in many ways to lack a defined space for the public’s role and as a result for the technological form of spacefaring to be determined far more narrowly than the cinema. Sheehan unpacks how spacefaring has been perceived in different ways and understood to have different meanings in terms of political paradigms used in international relations theory (Sheehan, 2007, Chapter 1). His point is to show that "The ambiguity and incompatibility of differing interpretations however lent itself to political exploitation" (Sheehan, 2007, p. 6). He sees what is called here the structural ambivalence of spacefaring as crucial to recognise in order to understand the political interest in space and its mechanisms of operation. Sheehan flags up the conceptual weakness of the claim of spacefaring nations to serve "all mankind" and the differences in interpretation of this phrase (Sheehan, 2007, pp. 6-7). His politically oriented focus, which remains on states and space agencies, reinforces the less agential positions of wider publics.

The idea of structural ambivalence used here, has some similarity with the idea of "mutual intelligibility" used by Punt (2000) in relation to the technology of early cinema, in that both phrases indicate an environment of actors, contingencies and technical capacities having an influence on technological form. But cinema had a clear place within everyday life and a clear relation to the decisions, choices, aspirations, and desires of the recipients – the cinemagoers. As a comparison, spaceflight perhaps held similar aspirations to fulfil the desires of the popular imagination as did cinema. Both share the capacity to be spectacles and to live, to a great extent, in the imagination. But while cinema catered for intimacy in many ways – in the content of films, in the seating of the audience, in the choice to buy a ticket – spaceflight never seemed capable of accommodating the position of the spectator and the intimacy of choices and values in the same way. In comparison, space technology, it can be argued has a troubled relation to its popular reception, proposing universal appeal but rarely providing a tangible space for its reception. An aspect of this troubled relation is a tendency to exacerbate differentiation and distinctions between popular and elite: the former as recipients and the later as determinants.

To trace the unity inherent in the idea of humanity and species proposed by, or clasped to, the technologies of spaceflight means to, in the same space, trace the disjuncture that is part of the pervasive ambivalence of space technology. The ease with which the singular idea of a unified humanity can be grasped through episodes of spaceflight history, reinforced often by live television broadcasts enabled by orbiting satellites (Parks, 2005, Chapter 1), can hide the corresponding experience of disjuncture. It is this more complex dimension that this chapter addresses. Possessing a satellite brings with it new capabilities and by dint, diminishes the capabilities of those not possessing a satellite. This fairly obvious distinction nonetheless hides the inevitable incapacity of spaceflight to unanimously serve humanity, because ownership of the spacecraft body inevitably causes a partitioning between the owner and the non-owner.

The view of Earth from space draws a strong desire to think in terms of mastery and conquest (Cosgrove, 2001). The philosopher and humanist Hannah Arendt draws attention to this in her writing of *The Human Condition* (1958) and *The Conquest of Space and the Stature of Man* (1963). She notices how the draw of an Archimedean point haunts the early exploits of spacefaring, The Archimedean point refers to the boast by Archimedes that given the correct point of purchase, he could lever the whole of the Earth out position. Implicit in this story is the idea that moving away from the Earth is accompanied by greater power over it, as the size of the planet diminishes with the perspective of distance. This diminishing of the size of the Earth, made a reality in the viewpoints attained through space travel, corresponds to an imaginary that since the early days of spacefaring has been linked in the popular imagination to the concept of pacific unity. The associations of the image of the Earth and the corresponding apparatus of space technology with peace and unity tend to camouflage those other associations with power and mastery that so concerned Arendt.

The first satellite: co-operation and competition

The worldwide project of the International Geophysical Year (IGY) that took place between July 1957 and December 1958 was a collective endeavour that captured a spirit of unity both through its instrumental programme of gathering data about the Earth's systems and the social processes of its co-ordination. It was a rare initiative with precedents in the International Polar years of 1882-3 and 1932-3 (Doyle, 2012, p. 13). The activities that took place during IGY drew an unprecedented number and range of participants from around the globe who worked together on experimental science projects. Their investigations probed the geophysics of the planet and were concerned with the oceans, land, atmosphere and cosmos in their relational unity. The grand scale of the experiments and the ambition of IGY called on the resources and expertise of scientists the world over. Its management was based on co-operation, on friendship and sharing with World Data Centres established in locations across the world from which the common goals of science could be pursued irrespective of national boundaries. This initiative can be understood as having been instrumental in generating future space programmes in many countries as it was also the vehicle through which the first spacecraft flew as probes gathering geophysical data (Doyle, 2012).

In the context of the International Geophysical Year (IGY) Sputnik was another instrument for understanding the Earth's upper atmosphere and both satellite and rocket launches bearing scientific instruments and tracked from ground stations were planned activities. In this context space programmes were a spin-off of the IGY as a report by the International Astronautical Federation (Doyle, 2012) highlights by examining the emergence and characteristics of space programmes pre-IGY and post-IGY.[54] Because a key aim of the geophysical year was to study the Earth's atmosphere, instruments were sent into the skies using sounding rockets (rockets fitted with scientific instruments launched into the sky but not escaping the atmosphere) and high altitude balloons, which both took readings through the strata of the atmosphere. In the mountains of Bolivia for instance Vikram Sarabhai, the future founder of the Indian space programme and future ISRO Chairman U. R. Rao worked on setting up an instrument to study cosmic rays hitting the Earth at the Equator and this was a shared experiment between India, USA and Japan (Shah, 2007, p. 97). IGY was reported to have been an exciting endeavour both in terms of the cosmic reach of the scientific research undertaken and for the teamwork inspired and enabled by the international spirit of cooperation (2007, pp. 96-98). The imagination of the International Geophysical Year in many ways embraced the idea of the Earth in a relation with its surrounding interplanetary space and by extension, embraced the idea of humans interacting with that environment and eventually going themselves into space. But at the forefront of the endeavours of IGY was a demonstration of an idea of worldwide cooperation as practiced in an exemplary way through science, by scientists.

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[54] This report details the emergence of national space programmes by categorising them in relation to the International Geophysical Year according to whether they began pre-IGY or post-IGY and assessing the impact of this initiative. The aim of the report is to assess the impact of the IGY initiative and it is published by the International Astronautical Federation to promote the benefits of international co-operation.

This meta-narrative of the science projects of the International Geophysical Year was given substantial notice in a speech to the National Academy of Sciences, Washington, D.C. in 1959 appraising IGY given by Dr. Hugh Odishaw, Director of the US National Committee for International Geophysical Year. In his speech he called the IGY programme the equivalent of "the Renaissance and the Copernican Revolution", not only for its science, but, "its social significance as a pattern of activity". Odishaw attempted to put across what the initiative meant in terms, not of the science, but as an activity of people, "as an activity of man without specific reference to its subject matter" that involved, co-operatively and voluntarily, 60 nations and "some 30 000 scientists and technicians". He described the enterprise as, "a gathering together of private human beings", notably placing validity on the individual as author of their work, "Thus the IGY was at root an enterprise of private persons, an enterprise in the hands of doers, and the form and shape it took largely reflect this." His testimony suggests that beyond the starker meanings documented in histories of spaceflight were diffused zones of meaning, affect and emotional responses which are more difficult to grasp and assess which constitute the interpretations and meanings of private persons. Odishaw recognises that collective endeavour does not take away from the authorship of the individual, or "private person", rather the collective is found to be constituted by myriad acts of authorship found at the small-scale level of many and various scientific inquiries and experiments.

Embroiled within the scientific initiative of the International Geophysical Year were the political-military concerns of the United States administration in relation to the question of Inter-Continental Ballistic Missiles. The ideological drive to understand the science of the environment was interrupted not only by technologist's ambitions to reach outer space, but also by the more familiar 'dual-use' paradigm whereby rockets and spacecraft could be used for military and political objectives. Evidence of the meaning of this small Soviet satellite to the United States Administration is found in official documents from meetings before and after its launch, which at the time were not made public (Gavaghan, 1998, p. 1). Spaceflight had a clear link to the making of Inter-Continental Ballistic Missiles (ICBMs) in that it proved the launch capability to set a missile in a trajectory that would travel at least halfway around the world.

During an intense discussion of ICBMs at a meeting in September 1955 Senator Hoover remarked that, "the earth satellite exercise had gone a long way to help the peoples of the free world realize that we were forging ahead in our technological capabilities" (National Security Council, 1955). Technological capability becomes at this time pivotal to political configurations and for the United States (US) the most important political configuration of the time was the division of the world between East and West, the division of those nations which support the United States – the free world – from those that support communism and the Soviet Union. The necessity of maintaining the starkness of that divide was mandatory and those nations that chose neutrality and remained non-aligned, were in many ways considered the most problematic of all. India was one of these nations and the friction between Prime Minister Nehru and US Secretary of State John Dulles over this issue is documented by the historian of post-Independence India Ramachandra Guha who reports on meetings between the two figures during 1955 (Guha, 2007, pp. 158-161). Senator Hoover's small remark recorded in the proceedings of the discussions of ICBMs observes the usefulness of the geophysical year programme to the military focus of the US administration. The significance of this link becomes apparent in a follow-up remark in which Hoover points out that without the demonstration of technological supremacy, which the Earth satellite programme would provide, the US would appear weak and with this "neutralism would advance tremendously throughout the free world" (National Security Council, 1955). The highest priority of the United States Administration was therefore to demonstrate convincingly its capability in ICBM's before the Soviets did because without this demonstration nations on the side of the United States might defer to neutrality, an option that in the mind set of the US administration was very far from benign.

Furthermore, President Eisenhower recognised that the Earth satellite programme of IGY would establish the precedent of freedom for satellites to traverse orbital space (Gavaghan, 1998, p. 1).[55] This was not for the altruistic reason of establishing a planetary commons but so that reconnaissance satellites could be launched to spy on Soviet territory. After the launch of Sputnik-1 on 4th October 1957 and a month later Sputnik-2 the United States government was

[55] Unlike air space that required permission from the sovereign nation before an aircraft could cross.

under severe pressure, by its own political reckoning, to launch its own satellites. The confusions and tensions of the dual motives of satellite launch come across plainly in the exchanges between policy-makers of the US administration. In this example of a meeting that took place on 5 December 1957 Secretary of State John Dulles challenges the cautious approach of the President's Science Advisory Committee to satellite launch in the light of the delay in launch the day before of the US spacecraft Vanguard TV-3.[56] Here Dulles demands that launches are not publically announced until they are successful, to which the Deputy Secretary of Defence Quarles remarks, "We had in our earth satellite program dedicated ourselves from the beginning to work upon this program as a scientific experiment" and that switching to unannounced launches could only happen "by changing our policy with respect to the fundamental purposes of our scientific satellite program" (National Security Council, 1957). What Quarles is sensitive to in his statements is the philosophical meaning of the launches, whether they are done in the spirit of the science project or as part of a political and military strategy. Discussions then continued as to whether the launch base could in some way be hidden from the public gaze of the Florida beaches. There is a sense within the documentation that exists of this meeting of both the huge political import perceived by policy-makers in satellites launches and also a moral question concerning the degree of openness to the ambivalences of spaceflight to which a government administration should be answerable to its people.

The intensity of meaning attached to satellite orbit is evident in the subsequent actions of the United States and Soviet administration's pursuit of their respective satellite programmes as devices of Cold War politics. The scientific satellite, ostensibly participating in the politically neutral and internationally unifying agenda of gaining knowledge about the planetary system and its cosmic interactions, was also used to achieve the contradictory aim of political

[56] The catalogue produced by Henry L. Richter (1966) of early satellite launches *Instruments and Spacecraft October 1957-March 1965* provides the following information. Vanguard TV-3 failed to launch on 6 December 1957. The US spacecraft Explorer 1 launched successfully on 1 February 1958 carrying a Cosmic Ray counter from the University of Iowa for an experiment led by Dr. J. A. Van Allen, who became famous for the significant discovery during IGY of the Van Allen Belt of meteors (and G. Ludwig). The satellite also carried Micrometeorite Detectors (of Air Force Cambridge Research Centre, Dr. E. Manring, Dr. M. Dubin). A backup Vanguard TV-3 was again unsuccessful in launching on 5 February 1958. Explorer 2 then failed to orbit on 5 March 1958. Vanguard 1 (Vanguard TV-4) successfully launched on 17 March 1958 and is still in orbit making it the oldest satellite in space. It contained no science instruments but had the objective of proving capability to launch. The next Soviet spacecraft to launch was Sputnik 3 on 15 May 1958.

advantage. This central fallacy between the popular idea of spaceflight heralding an all inclusive Space Age and the political drive towards winning the Space Race, is a key characteristic of the ambivalence of spacefaring enterprises.[57] As indicated in the introduction though, the artefacts of the ambivalences of spaceflight go far beyond the notional category of dual-use between scientific and military purposes. The philosophical question to which Quarles' comment draws attention only partially concerns use and is more fully accessed by addressing a field of affect produced by spacefaring perhaps even one that might accommodate without prejudice the gaze of someone walking along the beach near the Florida launch pad.[58]

Differentiation, segregation and criticality

In November 1960 *Seminar* journal published from New Delhi, India brought out an issue titled Into Space. The issue contained an editorial by Romesh Thapar outlining "The Problem" and

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[57] This contradiction of motives is detailed through a number of accounts, that mainly focus on the American space programme: Amitai Etzione's (1964) *The Moon-Doggle: Domestic and International Implications of the Space Race*; Bruce Mazlish (ed.) (1965) *The Railroad and the Space Program: an exploration in historical analogy*; Walter A. McDougall, (1985) *The Heavens and the Earth: A Political History of the Space Age*; Helen Gavaghan (1998) *Something New under the Sun: Satellites and the Beginning of the Space Age;* Michael Sheenan (2007) *The International Politics of Space*; Howard E. McCurdy (2011) *Space and the American Imagination* and from the Soviet perspective Asif Siddiqi has written a number of accounts including (2003) *Sputnik and the Soviet Space Challenge* and (2010) *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957*.

[58] The attempts at this time by the US Adminstration to guage public opinion about spaceflight are indicative of the gap that existed between those planning and executing space projects and a wider public. Documents of meetings at the time record two Pentagon consultants, Donald N. Michael and Raymond A. Bauer, giving their opinion on public reactions to launch failures in 1958. In their thoughtful assessment Michael indicates that any fear or hysteria was only experienced by those in the administration in charge of policy and that this group's liaisons with public commentary sources and media produced, rather than reflected, anxious reactions to the satellite's orbits. More than this, Bauer suggests that reactions to the satellite launch reflected or emerged from causes on a register not related to technology, science or international policy, but were instead connected with a concern for identity: "Our present reaching in to outer space may pose for us the problem of finding a new identity to match the new dimensions of the world." (International Affairs Seminars of Washington, 1958). The consultants discern spheres of influence for understanding the effects of Sputnik that have some correspondence with the arrangement of chapter 2-4 in this thesis: "1) the policy-makers in Washington, 2) the 'issue-makers' of the mass media and other 'authoritative' sources, and 3) the public at large" (International Affairs Seminars of Washington, 1958).

The consultants' struggle to assess the largely inaccessible viewpoints of the public can be compared to the first-hand account written in the autobiography *Rocket Boys* (1998) by Homer Hickman which was made into the film *October Sky* (1999). The story is about three boys whose lives change when they see Sputnik in the night sky and they begin to experiment in rocketry. The book gives an informal account of incidental effects of Sputnik's launch within everyday life. The author's parents for instance put on a Sputnik barbeque to look out for the satellite with neighbours (p. 32). Rather than the fear that the policy-makers suppose is caused by the launch, here is levity and genuine interest. The book shows how both levity and concern can also coexist, when the radio repeats the "bleep bleep bleep" the author's mother remarks: "it's going to upset your dad no end" (Hickman, 1998, p. 16). The viewpoint of the author reveals affect, but it is the kind that would not easily translate into a public opinion survey and is therefore a part of a register of affect elicited from spacefaring not easily accessed or accounted for.

then like all *Seminar* issues presented a seminar-style range of articles addressing aspects of this problem. Into Space has contributions on the technical, legal, political and societal aspects of the prospects of spaceflight. One is from Satish Dhawan then Professor of Aeronautics at the Institute of Science in Bengaluru, but later to become the second Chairman of India's national space agency the Indian Space Research Organisation (ISRO). Another is by J.D. Bernal whose book *The Social Function of Science* (1939) was, and is, a respected text in India, where there is a strong tradition of socialist interpretations of science.[59] The tone of the issue is on the whole measured and sober with J.D. Bernal cautioning on the tendency to link spacefaring to fantasy, saying, "It is very difficult to know how to write something about the Space Age to-day [sic] without reproducing involuntarily something already said by some author of science fiction" (Bernal, 1960, p. 27). Satish Dhawan sets out the technical requirements and feasibility of spacefaring. Nonetheless, in his editorial, Thapar is more forthright and cautions against the negative implications of the trajectory of spaceflight. Firstly he raises concern for the aspiration to control space implicit in the commonly used phrase 'the conquest of space' saying, "In this evolution towards an environment-controlling rather than environment-controlled being, man must now consciously and scientifically realise the consequences, and even the most indirect consequences, of his actions **before** they are taken" (Thapar, 1960, p. 11 — emphasis in original). Secondly, Thapar cautions that existing kinds of differentiation may be further exacerbated, "Poised on the edge of a new limitless frontier, man must recognise the dangers inherent in his differences and differentiations on Earth" (*Seminar*, 1960, p. 11). There is some hope in his reflections though that spacefaring may cause the opposite effect and he remarks, "It seems impossible that man, the Space traveller [sic], will be the same man who is 'backward', 'undeveloped' and unable to produce and distribute even the daily necessities of life for his fellow beings" (*Seminar*, 1960, p. 11). The sentiments of caution and hope present in Thapar's editorial begin to ask questions of a far greater reach than the technological, scientific or political.

[59] This is especially true in the socialist-leaning state of Kerala where the People's Science Movement took shape out of the science education activities of the KSSP group. When I attended the 13th All India People's Science Network conference in Thrissur, Kerala in December 2010, J.D. Bernal's books and image were in evidence. For further reference to the activities of KSSP see Patrick Heller (2005) 'Reinventing Public Power in the Age of Globalisation: decentralisation and transformation of movement politics in Kerala'.

How would the stature of the person and of humans in general be affected by spacefaring? For Hannah Arendt the launch of Sputnik presents an unavoidable problematic to her seminal analysis of *The Human Condition* (1958), which opens with a prologue contemplating the new age and new order that the Sputnik spacecraft augurs. She follows up the questions raised in the prologue a few years later in a paper entitled 'The Conquest of Space and the Stature of Man' (1963).[60] In this essay, Arendt probes the question whose interestes are represented by spaceflight and what it is that shifts for the species because of it. She notes in a similar way to Thapar how spaceflight presents an unassailable certainty that it must be progressive and raise the stature of everyone, "How can anyone doubt that a science enabling man to conquer space and go to the moon has increased his stature?" (1963, p. 45) she writes, but her argument is that in so doing spaceflight has segregated the scientists from layman or humanist, who are,

> … still trusting their common sense and communicating in everyday language [...] understand[ing] only what appears but not what is behind appearances (as though trying to understand a tree without taking the roots into account), and that their questions and anxieties are simply caused by ignorance and therefore are irrelevant. (Arendt, 1963, p. 45)

Arendt notices a potential inequity of stature posited by 'the conquest of space', that if true would enable the few to rule the many, the scientists to rule the laymen. In her essay is the

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[60] The phrase 'the conquest of space' had become common parlance in relation to spacefaring. Thapar questions the assumtions of this phrase in his comment on the "environment-controlling" trajectory of spacefaring (Thapar, 1960, p. 11). Arendt uses the phrase with deliberate ambivalence as it is in a similarly titled and critical article by Maurice Blanchot, the poetic philosopher and literary theorist. Blanchot wrote a short but perceptive commentary in 1961 called *The Conquest of Space* soon after Yuri Gagarin's flight (the Soviet astronaut who was first person to go into space), in which he calls attention to the dislocation of a person in space. For Blanchot, Gagarin was: "Man, but a man with no horizon", signifying Gagarin's absolute disjunction from the world and the rest of the species, rather than Gagarin as a representative of humanity whose experience could be vicariously owned by anyone. Blanchot perceived the "pure dislocation" of this spaceflight and more than this, a step away from what it is to be human, a step away from the home-Earth. For Blanchot, it is Earth as home that defines humanity. Spaceflight is therefore, in Blanchot's terms, a counter-evolutionary step. Blanchot sets up an argument against the presumption that leaving the Earth is the direction humanity should take: "Man does not want to leave his place. He says that technology is dangerous, that it threatens relations to the world, that true civilizations are fixed and that the nomad acquires nothing." (Blanchot, 1961). Blanchot's critical and in many ways dark text, reinforces that the phrase 'the conquest of space' had become common parlance and his essay can be interpreted as a challenge to the broad acceptance of the benefit and natural order of going into space as it had been presented through mass media of the time.

The origin of the phrase can be traced to publications of Willy Ley whose many books on spaceflight produced from the 1930's onwards include the titles *The Conquest of Space* (1949) and *The Conquest of the Moon*. The phrase became common due in some measure due to the author Willy Ley's partnership with Walt Disney in the production of a series of short films for ABC television network aired from 1955. In the television programmes phrases such as 'the conquest of space' and 'the next logical step' are frequently repeated and they are phrases that still form a common language of space mission rationales.

suggestion that the "pre-scientific question" is no longer valid, a prospect that she also writes cannot be true because scientists are also laymen, with many ways of comprehending the world, but the segregation she suspects, and that is pushed forward in the agenda of conquest, of which spaceflight is a spectacular part, is created by a science and technology that outruns the capacity to be comprehended, "the main problem, which is that man can *do*, and successfully do, what he cannot comprehend and cannot express in everyday human language" (p.46) Arendt's misgiving, prompted by the hubris over spaceflight, is that the quest for unity within the scientific project, (for universal laws and the subtext of survival of the species) is at odds with how it feels to live, "The categories and ideas of human reason have their ultimate source in human sense experience", she writes, and moreover they are formed in relation to the Earth. This observation reflects Arendt's close alliance with philosopher Martin Heidegger's formulation of the human as dwelling on Earth, under, or "receiving" the sky, rather than controlling it (1971, pp. 351-353). Arendt expresses an anxiety tied to the inability to opt out of, or disentangle, the technological project from its totalising ideal. Spaceflight is "glorious" but its meaning is "baffling":

> It was precisely by abstracting from these terrestrial conditions, by appealing to a power of imagination and abstraction that would, as it were, lift the human mind out of the gravitational field of the earth and look down upon it from some point in the universe, that modern science reached its most glorious and, at the same time, most baffling achievements. (Arendt, 1963, p. 48)

Arendt calls this perspective Archimedean recalling the statement by Archimedes that he could lever the world out of its place with the correct point of purchase. Arendt senses within the project of spaceflight an Archimedean will to power, the pursuit of an imaginary position of control, by a hegemonic and narrowly representative subset of humanity. She begins to perceive a disjuncture in social relations, between those who read appearances (the humanists and laymen) and those who look behind appearances (the scientists), and that the scientific way of thinking promoted in acts such as spaceflight, reinforces such segregation, or difference of opinion, without providing any means to demonstrate that such a differentiation is happening. Furthermore, the convincing demonstration of technical success reinforces the validity of a way of thinking and interacting with the world over others that do not own such a spectacular material proof. Arendt's essay points to the disjuncture caused by scientific world making and demonstrated in spaceflight that separates, types of world making, enhancing some and diminishing others, thus calling into question on what terms 'the stature of man' as a whole may have increased because of the conquest of space, or whether what has increased is the stature of only a few.

Arendt's attentiveness to separations that accompany scientific as opposed to experiential engagement with the world finds an echo in the writing of the visionary, Catholic priest Teihard de Chardin. Arendt's wariness for the exclusion of 'human sense experience' from the scientific viewpoint echoes de Chardin's premonitions, in which:

> Almost incurably subject and object tend to become separated from each other in the act of knowing. We are continually inclined to isolate ourselves from the things and events which surround us, as though we were looking at them from outside, from the shelter of an observatory in to which they were unable to enter, as though we were spectators, not elements, in what goes on. (de Chardin, 1955, p. 220)

Arendt's mistrust of the scientific over the experiential is close in meaning to the separation that de Chardin alludes to between subject and object and between participant and observer. De Chardin's writing however, unlike Arendt, is evangelically fuelled by the prospect of human ascension and his anticipation that the trajectory of the human species is moving onwards toward greater stature. In his book *The Phenomenon of Man* (1955) he refers to a defining point of convergence to which humankind is progressing. He argues that the discovery of dinosaur bones changed what it was to be human at the level of consciousness because the bones gave evidence of evolution. Humans, in his argument are therefore at a point on a trajectory of that evolutionary span that will, he anticipates, continue to produce further evolutionary shifts. The immanent prospect of space travel seems to hover around de Chardin's text as references to cosmos and space accompany his metaphorical reflections on ascendance, discovery and a superior existence for humankind. When he writes, "... to imagine, discover and reach this superior form of existence, we have only to think and to walk always further in the direction in which the lines passed by evolution take on their maximum coherence" (de Chardin, 1955, p. 234), he seems to long for an image to confirm the teleological certainty that humans are progressing to a higher level.[61] It is not out of place when he alludes to the "sidereal world" (1955, p. 257) – the constellations of stars – as the natural location of the next step in evolution. The ambivalence that is being described here, through the discussions by Arendt and de Chardin, are that spacefaring both sets up an expectation of an evolutionary, species-level shift and yet in the same gesture turns away from the home of Earth and the commonalities of sensorial experience that bind its peoples.

A connection can be drawn between Arendt's line of thought and a much more recent report on the state of spacefaring and space agencies by social anthropologist Diane Vaughan. Her thick description of the events leading up to the explosion a few minutes after its launch of the Challenger space shuttle in January 1986 points to fundamental differences between codes of practice inside the space agency and normal practice in the world at large. In her book *The Challenger Launch Decision: Risky technology, culture, and deviance at NASA* (1997) the cultural propensity of space agencies to segregate from the non-space agency world is tenaciously delineated. Her conclusions suggest that this is not so much a problem specific to NASA scientists but that groups, organisations, families even, produce their own frames of reference or worldviews that are specific to their operational spaces. In this way, Vaughan is able to assert that the opinions formed by the official accident investigation team did not sufficiently acknowledge the frames of reference in which managers and engineers were operating. Vaughan uncovers a process that she terms the "normalization of deviance" to account for the decision to launch (despite problems with the O-ring joint[62] voiced by engineers)

[61] The anticipated image of this "convergence" was in part supplied by Yuri Gagarin's flight in Vostok 1 in 1961 when he became the first human in space, but is perhaps more fully evoked in Stanley Kubrick's 1968 film, written with Arthur C. Clarke, *2001: A Space Odyssey*. The film begins in pre-history with a group of apes fighting for food and territory till one throws a bone-weapon into the sky that goes up and up into black space where it transforms into a spaceship. The imaginary (the film) and the actuality (Gagarin's flight) both appear to confirm a direction, into space, by which humans will achieve their next evolutionary step. The Moon landing in 1969 and Neil Armstrong's words only add to this notion that a collective shift in humanity "one giant leap for mankind" happens due to actual spaceflight. Reconfirming spaceflight as an evolutionary event, on the day of the Apollo launch the journalist Norman Mailer reports the words of the rocket engineer Wernher Von Braun when asked what the significance of the Moon landing was as: "I think it is equal in importance to that moment in evolution when aquatic life came crawling up on the land" (Mailer, 1969, pp. 33-4).

[62] O-ring joints are valves inside the Solid Rocket Boosters of the space shuttle. The joints are made of rubber and seal the valve when pressure is put on them. The cause of the Challenger space shuttle explosion was found to be the O-ring joints that had failed to seal because the temperatures were around freezing at the time of the launch making the rubber brittle. The engineers were concerned about the

that from the outside appeared negligent and wrong, but from inside, from the "native viewpoint" of those involved, were correct and carefully followed practices that since the beginnings of spaceflight had created a logic of practice that were part of the culture of the space agency and embedded in its history also. The exactitude of her revelations reveals cultural divisions between workforces collaborating on Challenger from which misunderstandings developed. To clarify that it was structural problems in the social processes of the space agency rather than an issue of 'nuts and bolts' and material failure that caused the accident, she makes evident the determining influence of analytical concepts such as 'native viewpoint', 'frames of reference' and 'worldview' in a compelling invocation of the social construction of technology. However, what her report does not dwell on is that these same revelations also indicate that there must inevitably be a much more fundamental separation of the space agency worldview from other worldviews: A specificity that it could be argued disqualify any possibility of the space agency acting on behalf of a larger humanity. While many kinds of blurring interrupt that reading, for instance employees are also family members and members of the public flexibly negotiating other worldviews, Vaughan's insights, wrested in the extreme circumstances of the accident, do convey the unavoidable segregation of the space agency from a wider milieu. This separation appears to be an inevitable consequence of the business of launching rockets and spacecraft.

Resistances to structural ambivalence

While differentiation can be understood to have developed in many forms as an accompaniment to spaceflight, so also did more overt forms of resistance to the ways spaceflight appeared to proceed from a narrow pool of participants able to benefit economically, politically and perhaps scientifically via the technological capability of satellite construction, launch and operation. One example is another text a United Nations document drawn up in 1976 called The Bogotá Declaration, which still remains unratified. This document draws attention to

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shuttle launching in freezing conditions, but had no data of how the O-rings would perform in these conditions to prove there would be a problem and cancel the launch (Vaughan, 1996).

an inequity between nations – an enhancement of some and a diminishing of others – at the orbital location called the geostationary orbit. The Bogotá Declaration was drawn up by eight Equatorial countries – Brazil, Colombia, Congo, Ecuador, Indonesia, Kenya, Uganda, Zaire – and is an eloquent statement of the emerging inequity caused by the technological advantage of nations with satellites in the geostationary orbit.[63] The clarity of language in this official text is used to full effect and conveys a seething anger targeted at the "industrialised countries" that continue to shape the rules to their own advantage, even in outer space:

> The solutions proposed by the International Telecommunications Union and the relevant documents that attempt to achieve a better use of the geostationary orbit that shall prevent its imminent saturation, are at present impracticable and unfair and would considerably increase the exploitation costs of this resource especially for developing countries that do not have equal technological and financial resources as compared to industrialized countries, who enjoy an apparent monopoly in the exploitation and use of its geostationary synchronous orbit. (The Bogotá Declaration, 1976, Article 1)

The claim of sovereignty is in essence a rhetorical stance – the real purpose of the document is its performance. The Bogotá Declaration provides evidence that as the nations able to launch satellites do so, they correspondingly affect the status of those nations not launching satellites. Without satellites in geostationary orbit these eight nations perform through the text the otherwise invisible, or disregarded effects brought to their nations by the launching of satellites by other nations.[64] Through the text the seven nations defend their people from the economic disadvantages of spaceflight. This use of space technology, "does not allow the equitable access of the developing countries that do not have the technical and financial means that the great powers have" (The Bogotá Declaration, 1976, Article 1). But the argument is not just about economics, the Declaration, notwithstanding its choice of clear, unambiguous language, is passionate and full of pride. Frequently, in space law, this document is cited and interpreted as

[63] The geostationary orbit is a circular orbit 37 000 kilometres above the Equator. At this height and position a satellite can orbit, staying above exactly the same location on the Earth. At this orbit the satellite is said to be 'synchronous' with the Earth's orbit so the orbit is referred to also as the geosynchronous orbit. Arthur C. Clarke is often credited with 'inventing' the orbit, so it is sometimes referred to as 'the Clarke Orbit' with reference to an article Clarke wrote in 1945 stating that in this orbit, three satellites could survey the whole earth at once (Wireless World,1945) Clarke writes, "A single station could only provide coverage for half the globe and for a world service three would be required, though more could be readily utilised". Henry Potocnik and Konstantin Tsiolkovskii are also credited with this idea.

[64] The Declaration in many ways reflects other kinds of imbalance between nations that become more noticeable during this time period for instance in tensions around the building of trade agreements.

being an "overstated claim" for sovereignty or otherwise misguided (Lyall and Larsen, 2009, p. 253). What is missed, by interpreting the document in that way, is that the Declaration is evidence of something more phenomenological than legal, that it points to the phenomenon of having and not having a satellite and how that feels. It points to the affective space of space technologies, which both enhances and diminishes. The fullest meaning of the document is not to be found in the logic of the text, or a literal reading, but through an appreciation of the lived circumstances that gave rise to its claim and language. When the writing of the document is understood as an opportunity within a limited spectrum of possible moves, the fullest meaning becomes evident. The existence of the document and its rhetorical resonance poses questions as to the nature of the affective space of satellites, the satellite footprint's "most remote and indirect consequences" (Thapar, 1960, p. 11) and what it is that the experience of having or not having a satellite translates into.[65]

Another critique of the problem of ownership and application of satellite technology is found in the formational projects of the Indian space programme, which began in 1962. As one of its early projects, run for one year between July 1975 and August 1976 the Indian space agency conducted the largest experiment anywhere in the world of using space technology for the least advantaged. The Indian Space Research Organisation, ISRO, addressed the emerging inequity of spaceflight as no other nation had by proactively designing an alternative model of spacefaring that foregrounded the needs of the non-elite, rural populations of India. The project was called the Satellite Instructional Television Experiment or SITE. In a film called *Space and India* released in 1971 by Vijay B. Chandra, the founder of the Indian Space Programme Vikram Sarabhai is filmed explaining his vision for a humanitarian and non-elite space programme in which a geostationary satellite would enable low-cost communication and television across the whole subcontinent. This very practical innovation in satellite technology led to the equally innovative social and technological experiment SITE in which television programmes devised specifically for rural populations were beamed to 2400 villages equipped with low-cost chicken wire receiving dishes [image] developed by the Indian Space Research

[65] I have made a number of performative artworks about the Bogotá Declaration some with Alejo Duque (Duque and Griffin, 2007-2010).

Organisation ISRO.

The Indian space programme has received attention for its distinctive societal emphasis (Sheehan, 2007; Harvey, 2000; Doyle, 2010), but it is rarely framed in terms of a resistant act critically reacting to the inequitable shaping of space technology in its first decades. Understanding ISRO in this way allows for the questions of who spacefaring is for to reach deeper. To explain this proposition, prior to the establishment of its space programme, India had, through the 1950's, defined its own distinctive position internationally through 'moral leadership' and a political 'third way'. In Ramachandra Guha's history of post-Independence India, Guha describes Nehru's visits to the United States and the Soviet Union and the resistance shown by Nehru to the intense pressure put on him to align with the United States (Guha, 2007, pp. 155-167). This independence of spirit is reflected in the kind of space programme adopted by India, which moved into an alternative, unoccupied ideological space: A societal space programme directed at enhancing the livelihood of its population, as distinct from a programme motivated by politics, power or military aims of the Cold War. The establishment of a societal space programme by India was nonetheless deeply political in that this assertion of a third way, of neutrality, of opting out of the US-USSR binary Space Race, was as has been pointed out, far from neutral. The U.S. administration would have seen India's neutrality as threatening to its own alliance of support. The historian Guha writes, "Nehru at first tried hard to avoid taking sides in the Cold War. But, as he often said, this non-alignment was not mere evasion; it had a positive charge to it. A third bloc might come to act as a salutary moderating effect on the hubris of the superpowers." (Guha, 2007, p. 164). Nehru's neutrality was not an opt out, it was a strong stance and one that was difficult to maintain in the face of the pressure from the United States to choose sides.

Understanding this background helps to put the establishment of a space programme in India in 1962 into some perspective. India established a 'societal' programme. The founding philosophy of the space programme is often linked to a speech in 1966 given by the Chairman Vikram Sarabhai. In this speech he stated, "man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed" (Sarabhai, 1966, 2001, p. 92). Put within the context of 'neutrality' and 'non-alignment' as a highly political and far from neutral third-way, the societal programme takes shape as a bolder move, an act of resistance, on the one hand against the pressure to choose between sides, and on the other hand, as a positive act in exercising the freedom to create a new imaginary of spacefaring. Perhaps also for Sarabhai, who had been active in the cooperative and disciplinary-led International Geophysical Year, the socialist ideology adopted for the space programme was also a protest against the co-option of scientific instrumentation for political gain. As noted by a later ISRO leader, "it is significant to note that the early inspiration for the Indian Space Programme came not from any military objectives, but from the interests of a large scientific community who have been actively engaged in research programmes related to geophysics and astrophysics" (Kasturirangan and Rajani, 2007, p. 1645). The origination of the Indian space programme within the ideology of international cooperation exemplified by the International Geophysical Year is also strongly present in the analysis of Romesh Thapar in 1960. In claiming a socialist agenda and societal remit the founding character of the Indian space programme was symptomatic of the deep flaws in the claim that spacefaring could be an activity carried out on behalf of all humankind. Instead of the idea of humanity, this space programme invoked the 'societal' as a more nuanced concept that could be practically addressed. The vision of this programme is captured in a short film called *Space and India* (1971) by Vijay B. Chandra that presents images of the burgeoning space programme (including orange Rohini rockets being assembled at Thumba in Kerala), alongside many other daily labours such as grain threshing, carrying water and raising children (Panel 4). The film, produced by Films Division India (part of the Ministry of Information and Broadcasting) is part of a surge in visual documentation post-Independence aimed at capturing a changing India and also instrumental in shaping India's future as a modern, resurgent nation by providing representations to which the nation could steer itself (Mohan, 1981).[66] Amongst the

[66] See also commentaries on the aesthetics of documentary films produced by Films Division in the 1970s by Mohan (1981; 1990), Narwekar (1992) Shai Heredia (2005), Amrit Gangar (2006), Garga (2007) and Gokulsing and Dissanayake (2013) as well as the Films Division catalogue compiled by filmmaker Pramod Pati (1974). In the film *Space and India* (1971) Chandra creates a distinctly Indian vision of spacefaring. It should be noted though that Chandra's vision of technological hubris changed considerably over the next several years. His more well known film *Child on a Chess Board* (1979) gives a dystopic rendering of technology perhaps reflecting the censorship of The Emergency that began in 1978 when technological modernity became evidently controlling and not liberating. Both films capture an imaginary

Panel 4

This Panel shows stills from the film *Space and India* (1971) directed by Vijay B. Chandra and produced by Films Division India. The images selected give a sense of the vision of the Indian space programme captured in the film, which invokes a modern Indian society in which rocket-making, scientific research and new large-scale technologies in the landscape are part of daily life alongside farming, carrying water, child rearing or praying. (*Images reproduced courtesy of Films Division India*) imagery generated were an image of a satellite carried on a bullock cart and a rocket nose-cone carried on the back of a bicycle, which became icons of a modern spacefaring nation re-imagined in India on its own terms both through the makeshift solutions of the engineering teams at Thumba and the visual production of filmmakers and photographers.[67]

The television experiment SITE was, in a similar vein, a demonstration of how India could invert the logic of political and economic elitism that seemed to characterise space technology by creating new rules of engagement that favoured the non-elite. In other words India constructed a space technology based on the determining needs of the technologically disadvantaged, the hitherto subalterns of spacefaring. The rooted morality of India's invocation of its people and the Earth through its space programme, by dint, exposed and devalued the belligerent aims of the Space Race in an act of resistance favouring those perennially disenfranchised by the preoccupations of spacefaring.

Fault lines and the first Moon mission by India

While this thesis follows to some extent the trajectory of the societal space programme, it does so through a further critique emerging from a real-world engagement. The story that is followed

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using editing techniques to suggest synoptic connections as if mimicking the flickering confusions of consciousness as scientists, technology, ritual and domesticity merge.

[67] The two images referred to – of the APPLE satellite being transported on a bullock cart and a rocket nose-cone transported on the back of a bike – appear in museum displays and publications about the Indian space programme. They capture the technological capability, resourcefulness and optimism of the nation inspite of economic difficulty. The French photographer Henri Cartier Bresson travelled to Thumba to photograph the new and at the time radical new vision of India's relation to technology emerging in makeshift shacks on the beaches of Kerala where Vikram Sarabhai first set up the ISRO (Shah, 2007). One of the photographs he took there was of the man riding a bicycle with a small sounding rocket nose cone strapped to the luggage rack. Apparently all the cars were being used to transport officials to the launch site and Bresson, himself getting around the site on a bicycle, photographed what may have looked to him an interesting incongruity. However, this image (and another of the APPLE satellite being transported on a bullock cart because of a problem with the metal container it was suppose to travel in) has become part of the iconography of India, telling its own story of engineering ingenuity, resourcefulness and optimism. Henri Cartier Bresson was at that time a well-known photographer with a highly distinctive style. He always printed his images with the black edges of the negative showing and never cropped so that the photograph conveyed the "decisive moment" captured in the negative. In the Space Gallery at the Visevesvaraya Industrial and Technological Museum in Bengaluru the photograph is displayed without a credit to Bresson and cropped to portrait dimensions, indicative of how the image has been appropriated into Indian space history and detached from its origins as the authorial work of Bresson.

begins in some ways with the launch in 2008 of the Chandrayaan spacecraft by ISRO. The launch of the spacecraft Chandrayaan on a mission to the Moon, which is a focus of this thesis broke the spell of that originating act of resistance and criticality evident in the space programme's championing of the societal. The mission instead followed the already established path of similar missions from the Unites States, China, Japan and the European Space Agency with similar purposes to map the minerals of the Moon. While doubtless impressive as a technological achievement, there was in the mission of Chandrayaan, no distinctive 'third way' being proposed and as a 'scientific' as opposed to 'societal' mission it offered no clear role for the technological subaltern. As such, the Moon mission represents a kind of rupture. It can be argued to have a closed the alterity of the Indian space programme. The redemptive move by the Indian space programme made to specifically include the subaltern within spacefaring, is called into question by the launch of the Chandrayaan spacecraft, which provides a fault line through which to address the limited capacity of space technology to translate societal needs and how this happened when the prospects for being societal and using space technology equitably had seemed so good. It will be argued that the launch of Chandrayaan produced anxieties connected to the ways in which the 'societal programme' seemed both threatened by the Moon mission but also exposed as perhaps already falling short in some ways. The journey away from Earth is used in this thesis to cast a light back and ask, through the lens of Chandrayaan, who spaceflight is for and to see how the structural ambivalence of spacefaring means that the actual success of being societal will always be called into question.

Summary

This chapter has outlined both aspects of the structural ambivalence of the purpose of spacefaring and consequences of this structural ambivalence that emerge as critical resistances, innovations and assertions of alterity. Some examples of criticisms and cautions as to the ideological trajectory of spaceflight were presented from the philosopher Hannah Arendt, the social commentator Romesh Thapar and from the founder of the Indian space programme

Vikram Sarabhai. What can be noticed is the entanglement of the extreme hubris over spaceflight in its early days with a less overt critique. Despite the apparently marginal voices of critique it appears these cautions did have a determining effect on technological form. The formation of the Indian space programme can be understood as a resistance to the growing elitism of spacefaring and the shortcomings of the claim that it is an endeavour for all humanity. The Indian space programme can be understood as asserting an alternative pathway for space technology by inverting the imaginary of the conquest of space. Instead ISRO focused on a coalescent aim of furthering scientific knowledge of the Earth and creating conduits of participation for the nation's most iconically grounded people (farmers and the rural population) to use space technology.

Chapter 2

The spacecraft from the viewpoint of the space agency

The previous chapter established that space technology is defined by its structural ambivalence which problematises a general claim made of spacefaring that it is acting for all humanity. A critique of this claim can be read into the formational philosophies of the Indian space agency's societal remit established in the early days of its space programme. The question of who spacefaring projects are for is now re-examined through the lens of the apparently anomalous mission of the Chandrayaan spacecraft which appears to renege on the Indian space programme's formational philosophy to serve society, by being instead a mission for scienctists.

The Chandrayaan spacecraft as an entity reveals a rich definition of its purpose and accountability in its relation to humans. This chapter begins to consider the question of whom spacefaring is for and what it is for by looking closely at what it is that the technological object reveals from the viewpoints of those who use it. This is done through a three-part study of the spacecraft from distinctive vantage points. The first part, presented in this chapter, focuses on those scientists, engineers, technicians, managers and support staff involved in the making of the spacecraft. The second part focuses on the vantage point of the state and the third part considers affiliations of those not included in either of these accounts, those others often referred to as the public, who in general are characterised by their alienation from spacefaring projects. The spacecraft is considered as having an identity dependent on viewpoint and one that is therefore to some extent flexible according to who is looking. Through these viewpoint shifts the spacecraft is found to be at times a scientific instrument, at times an apparatus of state and in other contexts a cultural technology capable of many other kinds of re-appropriation. As a way of accessing such viewpoints the experiences of those producing the spacecraft is emphasised. This becomes a way of accessing the vantage point of individuals and in this chapter the variety of ways the spacecraft is experienced within the space agency itself.

This method of looking at the spacecraft from different vantage points is called here a technography and follows Steven Woolgar's (1998) suggestion that a 'technography' puts emphasis not on objects but on their uses. A technography thus focuses on persons and the activation of social processes in relation to the technological object and de-emphasises the object itself.[68] This chapter will begin with an introduction to the term technography through the discourse of technological objects that builds on a social constructivist approach, leading into more complex readings of the relations between the social and the technological that become evident in the 'real-world' social space of the specific example of Chandrayaan. The notion of a technography is introduced, followed by the first part of the technography which focuses on the relation of the spacecraft to its makers – the scientists, engineers and technologists most closely associated with the material construction of the spacecraft body and its supporting infrastructure.

The spacecraft body can be considered in relation to the experiences of those designing, making and operating it. The construction of the spacecraft can take many years but the close contact with the spacecraft during that time contrasts considerably with the experience of the spacecraft after launch when it is operated remotely. A technography of experiences creates a slightly different view than the technography of use and social processes that Woolgar's suggests. In the technographic approach taken here it is the particularity of the experiences of a spacecraft that is emphasised. To guide this approach the recent work of social theorist Gopal Guru and the philosopher of science Sundar Sarukkai (2012) is drawn on to open a reflective discussion stemming from a question posed by Sarukkai, "Is an individual the author of her experience?" (Sarukkai, 2012, p. 38). Although the work by Guru and Sarukkai addresses the ethics of

[68] An example of the application of this approach can found in Paul Richards' study (2005) *Plant Biotechnology and the Rights of the Poor: A Technographic Approach*. A further critique is available has been written by Jansen, K. & Vellema, S. (2011) titled *What is Technography?*.

theorising Dalit experience, which is the experience of the Untouchable caste in India and therefore very far from the subject of orbiting spacecraft, the insights and provocations of their argument have an uncanny resonance for the present discussion of a distant and on many levels untouchable spacecraft. The ethics of making such a link between the realities of untouchability (the Dalit experience) and the precious, prized object of the spacecraft are precarious and yet making this connection moves to the core of asking who spacefaring is for by asking how subaltern experience (experiences less valued or apparent) is accommodated within space enterprises.[69]

In order to orientate the discussion, this chapter will begin with an introduction to the term technography through the discourse of technological objects that builds on a social constructivist approach. This leads into more complex readings of the relations between the social and the technological that become evident in the 'real-world' social space of the specific example of Chandrayaan, which are better accessed through approaches that can incorporate the dimension of experience, authorship, agency and biography.

Theoretical perspectives on technology

The sociologist Steve Woolgar describes a technography (1998, p. 444) as a "perspective" with which to unpack the social relations frozen into technologies. By this he means that because technologies are designed to meet human needs, uncovering the derivations of formations of technologies must tell a story of the kinds of beings that humans are. So Woolgar calls technology "applied social science": The practical outcome of contingent and often difficult to grasp currents of social relations. Technologies are full of clues about people and they comprise he says, "an amalgam of social relations" (1998, p. 444). In his paper titled *A New Theory of Innovation* (1998), Woolgar considers technology and innovation as aspects of social relations and social processes. Woolgar notices that technologies have a focal point, a key type of user for which they are configured or designed. In a sense it ought to be possible to interpolate from

[69] A fuller discussion of the term 'subaltern' is made in Chapter 5.

the object the characteristics of this user. But he adds to this that technologies are not always produced in innocent forbearance to user needs. In the market place, technologies, through marketing strategies, in many ways "configure the user" so that people become persuaded that they need new things (1998, p. 444). To add to Woolgar's insights, users can also find they can adapt their own needs around available technologies, in other words configure themselves to existing technologies. What is interesting here is that there can be focal points of 'rightness', or certainty, at which a user can feel satisfied in their ability to use a technology for their own particular needs. It is where this point of satisfaction is met that is of interest to the discussion of who spacefaring is for, because this helps to see whose needs are met and whose needs are not met by space technologies.

Woolgar introduces into the discussion of technography the notion of there being a 'certainty trough', an idea developed by his colleague Donald MacKenzie (1996), which he describes as a U-curve that can be drawn on an x and y axis, according to which those nearest the technology, the makers, can have much uncertainty about the product, those further from the fabrication will often have complete confidence in the product and are situated in the trough of Woolgar's diagram, while those at an even greater distance, again show signs of uncertainty and feel alienated from the hubris over the latest technology. He gives the Macintosh computer as an example of what he means:

> Macintosh devotees, firmly situated within the trough, are configured users whose confidence in Macintosh products is greater than those actually designing and producing them. Yet further away from the site of Macintosh production, we find the disaffected adherents to the PC standard. They manifest an uncertainty bordering on disdain. (Woolgar, 1998, p. 445)

There is empathy of sorts in this model between those closest to the technology and those furthest away, both experiencing uncertainty. A similar distribution of certainty and uncertainty could be mapped onto a technography of the Chandrayaan spacecraft with those working close to the spacecraft experiencing the vulnerability of the technology they are involved in making, whilst officials from governmental bodies are often situated firmly within the 'certainty trough' expressing absolute certainty in the legitimacy of the spacecraft mission, while those at a greater distance, able to access the certainty expressed through public media, but unable to themselves connect with or satisfactorily use the spacecraft, may inevitably feel an alienation from the project, bordering sometimes on disdain. To add to this formulation by Woolgar, there may also be the possibility of others who might turn their disdain and feeling of alienation around by re-imagining themselves as the configured user of the spacecraft somewhere else along the U-curve, perhaps even at multiple locations on the U-curve, and who use the spacecraft to develop their own particularised agendas, in less publicised ways. It is to look for the possibility of such renegade configurations that a technography of Chandrayaan is built across the next three chapters. However, it is through the notion of the three groupings of the 'certainty trough' that the three chapters are arranged. The focus of this chapter is another group – the 'scientist-makers' – the equivalent of the Macintosh designers and producers who Woolgar describes as having a unique view of the vulnerabilities of their products: the scientists, engineers, technicians and managers designing and producing the actual spacecraft.

To look for some of the origins of Woolgar's approach to technology, twenty years before the writing of this paper, Woolgar worked on a book with the social anthropologist Bruno Latour that examined the construction of scientific facts through direct fieldwork observations of a biological laboratory. The book *Laboratory Life* (1979) was a remarkable study because methods of anthropological enquiry usually used to study social groups far from the modern metropole, were in this study turned onto the social practices of a modern scientific laboratory bound by the kinships of the professional workplace and of their scientific inquiry. Latour and Woolgar examined the nature of scientific inquiry as anthropologists, drawing conclusions from observable and recordable actions and speech taking place in front of the researchers watching life in the laboratory. In this way, one of the predominant activities of the scientific laboratory was unexpectedly found to be "inscription", in the form of writing on sample bottles, on animals, in log books, the recording of results, the writing of papers and the secretarial work involved in copying and distributing texts. In a parody of observational scientific inquiry, Latour and Woolgar followed the emergence of a scientific fact, allowing the process to describe itself through their empirical observations rather than pre-empting a definition of a scientific fact. In following the 'discovery' of a substance called TRF they notice how the agreed 'fact' appears amongst a 'noise' of many alternative solutions in such a way as to lack the definition of a clear fact and instead to have been established as much through social consensus as clear measurement. The naming of the fact or discovery of TRF then has consequences in that the substance TRF is changed, not materially, but in its use, and in what the substance was thought to be:

> The crucial point we have tried repeatedly to stress in this chapter is that once one and only one purified structure has been chosen out of all the equally probable structures, a decisive metamorphosis occurred in the nature of the constructed object. (Latour and Woolgar, 1979, p. 148)

This "constructed" object marks the beginning of an approach to science and technology that foregrounded its social construction, an idea that went against the claim of science to be objective, pure and independent from the vagaries of subjective interpretation. To illustrate their point through another example, Latour and Woolgar follow the emergence of a new idea in the lab and show how the supposedly 'eureka' moment of having an important breakthrough, had in reality emerged through a number of discussions and suggestions traceable through a network, revealing how significant breakthroughs that seem to come from one person, are distributed and shared through social processes. The new idea, or the scientific fact, could, Woolgar and Latour asserted have had a number of alternative outcomes. There was not one singular, observable world they contended that required discovery by scientists, the world was instead constructed or invented to some extent through the practice of science and could be constructed in a number of alternative ways. Thus, Latour and Woolgar made the contentious but seminal claim in their book that scientific facts were socially constructed.

This research was used to make a similar claim for the social construction of technological artefacts. In an essay on the evolution of the bicycle design, Trevor Pinch and Weibe E. Bijker (1987) argued for ways that social user groups determine technological form. Firstly they gave definition to what they meant by a social group by stating, "that all members of a social group share the same set of meanings, attached to a specific artifact" (1987, p. 30). They then considered the bicycle in relation to several social groupings with shared characteristics, such as racers who wanted to go as fast as possible or female cyclists. Pinch and Bijker then plotted diagrammatically the link between social groups, the problems they found with the existing bicycle designs and the eventual evolution of solutions through the course of many years of redesign. In the process they demonstrate that the design could have followed a number of different courses which they term the "interpretive flexibility" of the design process, into which users can intervene and become active agents in determining technological form. This was similar to Latour and Woolgar's observation of the many possible 'facts' from which only one was chosen in the laboratory and the ways that the appearance of a scientific fact could be shown to have some dependency on social processes.

By demonstrating that social forces had shaped a technological artifact, Pinch and Bijker could dislodge the prevalent 'technological determinist' view that new technologies changed societies. Instead they could demonstrate how societies had agency with which to affect the form and emergence of new technologies. The critical theorist Marshall McLuhan for instance advocated from the largely technological determinist viewpoint that new technologies brought social change, if not revolutions. In his books, teaching and television interviews McLuhan reflected particularly on the new media of mass communication such as television and telephones of which he stated that 'the medium is the message', meaning that technology determines what can be communicated and that new forms of communication emerge after the invention of a new technology. Pinch and Bijker's study in some ways demonstrated the opposite that technologies could be determined in response to the existence of certain needs and thereby followed the patterns of existing behaviours and desires. For instance it could be argued that the World Wide Web formed because there was an existing need to communicate and share globally and the form of the Internet has adapted towards this need. The technological determinist perspective would argue that the World Wide Web initiated a change in behaviour. Both processes are doubtless at work. The theory of the social construction of technology challenged the notion that technology led change and in so doing opened a space for social imaginaries to both precede form and to be determining form. So the claim of social construction was an important stage in understanding the entanglement of people with things. Different theoretical perspectives of the interactions of persons with technologies observe and allow for different levels of agency or participation.

While Pinch and Bijker's essay made important claims for the social construction of technology, the 'user' was more thinly constructed, drawing on narrowly formed 'user groups' such as women or racers. An image used in the essay of a man and woman on their bicycles, supposedly cycling, but clearly in a staged photograph with a painted backdrop and wires holding their bikes upright, sounds an alarm for the shortcomings of their argument that attempted to combine the social and technological but failed to account for the particularity of the human subject. Arjun Appadurai's edited anthology *The Social Life of Things* (1986) that addresses the relation of commodities (of which technologies are a subset) to persons allows for a far more animated and complicated set of relations and processes to bind people with things that the title makes explicit. The idea of things having social lives admits the agency not only of users but also of the objects themselves and draws attention to the ways objects change as owners apply their own values to their possessions. This approach takes the viewpoint of the object and in so doing allows for a multiplicity and particularisation of individual uses and interactions to be accounted for. Considering technologies through their social lives however seems inappropriate to the life of a large-scale and remote technology such as a spacecraft, an entity strongly characterised by a distanced relation to commerce and other kinds of social exchange, everyday use and touch. Nonetheless the Chandrayaan spacecraft can still be said to have a social life, a celebrity status even, through which many types of uses, meanings and attachments can be formed.

Writing in a chapter that examines the social life of a nuclear bomb, Sankaran Krishna (2010) uses Appadurai's framing of luxury goods to theorise the position of nuclear technology in relation to a scarcity of materials for its development and a minority elite determining the decision-making processes leading to its production and in effect owning the technology. A similar pattern exists, he suggests with other kinds of large-scale technologies adopted as part of a development agenda in India post Independence in which, "What emerged was one of the most dedicated and ascetic attempts by an upper-caste elite to develop an entire country while by passing the social" (Krishna, 2009, p. 77). Characterised by a limited usership, Krishna finds that the evolution of the design of nuclear technology reveals deep-held anxieties of a narrow social strata of aspiring middle-class professionals projected onto the larger populations for whose benefit it is ostensibly created. What he proposes is a disturbing link between political support for the bomb and the deep-seated rejection by such classes of the majority of the Indian population: Its "overpopulated" society. Here it is not the use of the technology that is in question so much as what it is that the anachronistic development of an atomic bomb can reveal about the agencies that brought it into being. Krishna's study opens the possibility of seeing within the development of a large-scale technology evidence of a malaise on a different register. Space technologies could be read for similar evidence of a malaise elsewhere. In the Indian space programme, similar tropes can be discerned, for instance in a speech by ISRO Chairman U.R. Rao in which he refers to the ways space technologies can rid India of "the pollution of poverty" (Rao, 2006), can begin to be understood as perhaps part of the same malaise identified by Krishna in respect of nuclear technology. This kind of analysis of technology can be called heuristic and unlike some of the theoretical perspectives discussed earlier, here there is no specific theory being developed, rather, the technological artifact supplies a medium by which to access processes operating on another register. As another layer, the use made of nuclear technology by the scholar Sankaran Krishna could be added to the social life of the technology.

The discussions, activism and writings of the psychologist and social theorist Ashis Nandy, together with a group of sociology scholars based around Delhi in the late 1980's, laid out the problematic and worrying entanglement of persons with technologies that emerged from post-Independence development projects in India. Throughout the collection of essays in *Science, Hegemony and Violence: A requiem for modernity* (1988), technological projects produce violent effects such as displacement from home and land. In the collection of essays Shiv Visvanathan describes technoscience as "vivisectionist" experiments on populations in which risks from new fertilizers, medical treatments or the construction of dams are extended onto recipients with unknown long-term effects (Nandy, 1988, Chapter 8). In these cases populations affected by such large-scale technologies of which nuclear power, dams, heavy industries and space technology can be included, are strongly characterised by the extremely limited spaces of agency given to recipients to determine technological output or form. Affected groups can protest but their requirements are only incorporated into redesigns through drastic, sometimes life-threatening action. The social activist and writer Arundhati Roy makes the limited space of populist agency within large-scale technological developments clear when she speaks up for the "public power" (Roy, 2005, pp. 281- 325) of protesters and activists resisting technology. Nandy takes the limited space for dissent within the construction of large-scale technological projects to be a defining feature of large-scale development projects. Little wonder that recipients of such technologies, which are modeled on "theatrical science" and the "illusion of spectacular development" (Nandy, 1988, p. 9), can only effectively respond with similarly visible spectacles of protest. These contributions to the discourse of technology underline a loss of agency in which accounts of recipient's experiences of harmful technologies have to be performed in extreme circumstances in order to shape the technology more favourably to the lives of the people they affect.

Such characteristics and circumstances are not confined to India, the development of large-scale technologies in India is absolutely connected to similar developments elsewhere. Moreover, the delimited spaces of agency to determine technological form have been recognised as a repeated characteristic of large-scale infrastructures. In an essay that demonstrates how satellite technology as a large-scale system delimits participation, Lisa Parks (2012) shows how the domestic satellite dish, from what she terms "a populist approach" (2012, p. 64) is the only tangible component of the large scale infrastructure of the direct broadcast satellite system that is otherwise impossible to imagine or grasp. Parks calls the dish a "portal technology": A component that provides access of sorts to the larger network, but at the same time indicates the lack of personal agency of the user or owner of the satellite dish over the construction or form of the network. Similarly, Rosalind Williams (1993) considers the origins of large technological systems within the visions of Enlightenment projects in which everything was done in the name of 'the people' and for the benefit of the public. But she concludes that despite the optimism of such originating philosophies large-scale technological systems continue to fail to reach the human subject in its fullness. She concludes that direct experience is the only means by which to counter this lack of accommodation and following the work of Michel de Certeau (1984), suggests that walking through and experiencing first-hand can perhaps be the only way of countering the lack of determining agency available to recipients of large-scale systems. Williams suggests that such acts as walking in which the body is used defiantly can counter the insufficiency of the large-scale system to accommodate the human subject in its fullness, she writes, "If, as Foucault asserts, the body is the irreducible element in social organization, then carving out an unpredictable, individual trajectory through the creation of an alternative pathway is an implicit act of defiance" (1993, p. 399). For Williams, in the extreme cases of large technological systems, it is through a bodily assertion of a relation to the technology that a stake in its construction is attained and this is similarly affirmed in the writing of Nandy, Visvanathan and Roy.

Through such theoretical perspectives, the technography of the spacecraft that is unfolded over the next chapters will delineate experiences and uses of the Chandrayaan spacecraft so that the spaces, silences and agencies of intervention and interaction become apparent. The theoretical perspectives presented propose a range of possible terms for interaction with technologies and a range of optimistic to extremely negative capacities to author, reinterpret, appropriate or redesign technologies that enter the public realm. These theoretical perspectives emphasise where spaces of agency exist for designers, users, recipients, producers, owners, etc. and also where obstructions exist. The question is to whom these spaces of agency provide a level of ownership, or participation, or negotiation. In the case of space technologies, to whom is this technology configured towards and who is it configured away from and for what purposes? To what extent can a person configure himself or herself towards the technology if they choose to and to what extent are they inhibited from this? Within the proximal zone of the production of the spacecraft Chandrayaan there appears a uniquely customised and close correlation between the makers, the technology and the users because the makers – the scientist teams consisting of many kinds of specialists – are constructing an instrument for their own experiments and therefore their questions and expertise would appear to be fused into the technological structure.

By looking next in detail at the process of the spacecraft's production, some of those spaces of agency will be examined as well as the expectation that the science teams are indisputably fused to the technology and its mission and how and where that expectation of connection falters. This will be an intimate reading of the social construction of the spacecraft during its most proximal contact with humans, through which a rich definition of the purpose and accountability of the spacecraft is gradually revealed.

Chandrayaan from the viewpoint of the scientist-makers

The following narrative of Chandrayaan is drawn from a collage of sources including interviews and information gleaned during the author's research practice in which she worked collaboratively with a number of ISRO personnel involved in the Chandrayaan mission. It presents a narrative of the life of the spacecraft and its stages of production through the experiences related first-hand of those working directly on the project, and supplemented with other sources. The account is from the perspective of the 'scientist-makers'. This term encompasses the many personnel and specialists who work directly on the design and fabrication of spacecraft. The terms scientists, engineers and technicians fail to account for the varieties of specialism and their overlaps found within the space agency workforce. Scientists working with space technology are sometimes called space scientists. There are also planetary scientists, astronomers and astrophysicists. A television documentary titled *How to Build a Satellite* (2011), which presented the construction of a communications satellite through interviews and film sequences of stages of the work, included the following personnel – integration technicians, team leader, propulsion systems engineer, site director, head of manufacturing, hybrid technician, electronics engineer, industrial chemist, test engineer, integration manager, thermal architect, project manager, production manager. A scientist who works with an instrument on a spacecraft is constructing an experimental apparatus to test a hypothesis and may be called an experimental scientist. The link between this kind of scientist, and an engineer or technician may be stronger for the experimental scientist than for the purely theoretical scientist because the experimental scientist has to have the engineer's tacit understanding of material in order to make devices work. The historian of technology Eugene Ferguson (1977) writes of the tacit knowledge of the engineer being non-scientific but based on judgments and experience not accounted for within science and more akin to artistic sensibilities, saying, "All of our technology has a significant intellectual component that is both nonscientific and nonliterary" (1977, p. 827). The intellectual work of making the spacecraft is difficult to categorise using the terms scientist and engineer not only because of the range of practical, science, mathematics skills needed but because of the ways these become shared and diffused through the workplace teams.

Spacecraft technology is fragile and risky involving high precision work, long time periods and huge investment. The NASA project manager and researcher Charles J. Pellerin (2009) uses the example of the mirror failure on the Hubble Space Telescope in his book *How NASA Builds Teams* to indicate the overwhelming psychological weight of such missions on their teams. It is not only the material technology that is fragile in these enterprises but the inseparable investment of its workforce. Besides the scientific and technical, much of what happens within the space agency workplace is organisational and procedural in nature. In an article on mission planning authored by ISRO directors Adimurthy, Prasad and Shivakumar[70] (2007) they describe, "... a complex and multi-disciplinary activity, which spreads from definition of mission objectives to the end of mission life" (2007, p. 1791). Systems of management produce spacecraft as much as scientific or technological know-how. Space agency workforces that can appear to be narrowly constituted from the disciplinary areas of science and technology, excluding for instance the arts and humanities, are, in their own terms, richly interdisciplinary.

The beginning of Chandrayaan for the scientist-makers could be said to have started in early 2000 when a detailed proposal for the mission began to be written, but the idea of the mission had been in the air for many years before. The reply often given to the question of why the

[70] When the article was written V. Adimurthy was associate director of the ISRO Vikram Sarabhai Space Centre in Kerala; M.Y.S. Prasad is Director of the launch pad at Satish Dhawan Space Centre at Sriharikota in Andhra Pradesh; S.K. Shivakumar was Director of ISTRAC, the tracking wing on ISRO, located in Bengaluru and has since become Director of the SAC Satellite Applications Centre also in Bengaluru where spacecraft are fabricated.

decision to work on a Moon mission was made at this time, tended to be that the time was right in that ISRO had built up the capability to embark on such a mission. ISRO had created a substantial remote sensing operation and a range of societal applications were also well established elements of the space programme. Chandrayaan was one of a new phase of space satellites geared towards science.[71] Other similar spacecraft that also began to move into production, though on a much slower timescale than Chandrayaan, were Astrosat (a space telescope) and Aditya (a sun observing satellite). The proposal stage involved extremely detailed plans of how the spacecraft would be fabricated itemising sources of materials and expertise and basically proving that such a technological feat was possible.

This stage also involved developing a scientific rationale which was led by the lunar scientist Narendra Bhandari, based at the Physical Research Laboratory in Ahmedabad, who had been one of the few Indian scientists to work with lunar samples from the Apollo missions that were given to India in the 1970s. The proposal gave the rationale as to why the mission should happen, what would be its purpose and provided the technical design and the organisational plan to demonstrate that the necessary workforce and expertise were available. The proposal also established that a sufficient user-group existed, of academic scientific researchers who would use the spacecraft's data. To create this support from the scientific community nationally a number of large meetings were held which aimed to galvanise support.[72] These meetings of scientists such as those in Bengaluru (2003) and Udaipur (2004) appeared to include scientists' opinions in the development of the mission, although from the point of view of some scientists

[71] Most previous satellites launched by India had been what were called 'societal' or 'applications' satellites. These included communications satellites used for data, television and phonecalls (the INSAT series), remote sensing satellites (the IRS series) that image the Earth in different wavelengths for geophysical information, weather satellites and navigation satellites. In a speech by K. Kasturirangan (Chair of ISRO 1994-2003) titled 'Applications of Space Technology' he begins: "The Indian space programme is recognised today as one of the most successful in the world...in utilising these technologies for the direct benefits of the society. I am happy to present before you, the emphasis given to applications of space technology that has important societal implications" (2009, p. 37). Although by the time Kasturirangan made this speech, Chandrayaan had launched and was at the Moon he did not include it in his talk. The line between an 'applications' or 'societal satellite' and a 'science' satellite being clearly drawn, at least in the rhetoric of ISRO. Chandrayaan was one of three new space science projects the others being Astrosat (a space telescope) and Aditya (a Sun observing satellite).

[72] One of the key meetings was the 90th Indian Science Conference held in Bengaluru on 3-7 January 2003. A report of the conference (2003), relates speeches by the President A.P.J. Abdul Kalam and the Prime Minister of India Atal Bihari Vajpayee and by K. Kasturirangan the Chairman of ISRO and President of the Indian Science Congress Association. Another of the key meetings was the international conference held in Udaipur, Rajasthan the International Conference on Exploration and Utilization of the Moon November ICEUM-6 22-26, 2004. It was here that a model of Chandrayaan was first displayed.

present the large, one-day meetings gave little actual feeling of direct participation or influence. The establishment of support from the academic scientific community for the mission significantly helped in gaining approval and made the path through government straightforward. The process of seeking government approval happens for every satellite, but for Chandrayaan the process was longer, because it was a different kind of mission. A mission to the Moon had never been attempted before by the Indian space agency and it required a new discussion, in part about the appropriateness of this kind of mission for India, but also because it needed to elicit the support of a new user group. Therefore, a blueprint of the actual spacecraft was first constructed in the written proposal.

When the government in 2003 allocated funds, work began immediately under the pressure to complete within four years. Tasks were divided, team leaders appointed and teams assembled. Chandrayaan carried a number of scientific instruments, which are also called 'payloads' or 'experiments'. ISRO teams were responsible for five of these instruments and a call had been put out internationally for other experiments.[73] The instruments were experimental apparatuses designed to test hypotheses and would ultimately lead to new knowledge presented in peer-reviewed papers. Each instrument has a Principal Investigator who oversees the design of the instrument and the subsequent analysis of data. One of these instruments, the C1XS experiment (Chandrayaan-1 X-ray Spectrometer, pronounced "kicks") was built to measure the reflection of sunlight from the Moon's surface in order to ascertain from reflected light the signatures of different minerals on the lunar surface. This technique of measuring reflected light in order to ascertain chemical compositions is called spectrometry. Each mineral composition reflects a unique 'signature' of light and this property has meant that distant stars and galaxies when

[73] Five instruments on board Chandrayaan were designed by ISRO teams, five by teams from elsewhere and one by a joint Indian/international team. The instruments, or payloads are they are called, are as follows: the Chandrayaan-1 X-ray Spectrometer: CIXS (India-Europe team); Terrain Mapping Camera: TMC (India); Hyper Spectral Imager: HySI (India); Lunar Laser Ranging Instrument: LLRI (India); High Energy X-ray spectrometer: HEX (India); Moon Impact Probe: MIP (India); the Sub-keV Atom Reflecting Analyser: SARA (European Space Agency); the Moon Mineralogy Mapper: M3 (Brown University and Jet Propulsion Laboratory, funded by NASA); a near infrared spectrometer: SIR-2 (European Space Agency including Max Planck Institute for Solar System Research, Polish Academy of Science and University of Bergen); Miniature Synthetic Aperture Radar antenna: Mini-SAR (NASA Naval Air Warfare Center, Johns Hopkins University Applied Physics Laboratory, Sandia National Laboratories, Raytheon and Northrop Grumman); Radiation Dose Monitor Experiment: RADOM-7 (Bulgarian Academy of Sciences).

examined as spectrograms reveal quantities of information about the composition of and evolution of the cosmos. The C1XS instrument took measurements from the x-ray spectrum of light (Grande et al, 2009; Narendranath et al., 2011) other kinds of light in the spectrum are infrared, ultraviolet, gamma rays as well as visible light. Observations made of different parts of the full spectrum of light give different information and can be compared and integrated to give fuller pictures of what exists beyond the reach of the visible light humans can see. The impressive photographs of galaxies produced via the Hubble Space Telescope are composites of this kind. Multiwavelength astronomy, as this technique is known, is therefore the backbone of astronomy research. In studying the composition of the lunar surface, samples brought back from missions such as Apollo have formed a basic data set, but these samples came from only the mid area of the Moon. Remote sensing missions – that is spacecraft orbiting and gleaning information through techniques such as spectrometry away from the surface – have since added new information to map the mineral surface. Each measurement technique however has limitations of one sort or another and it is only gradually that a picture is built through analysis, comparison and speculation of the geological landscape of the Moon. The C1XS scientists defended the x-ray spectrometer's ability to add to current knowledge as a method that could confirm other as yet inconclusive experiments:

> In this context, X-ray remote sensing provides a platform for unambiguous and unique identification of signals from the major elements and estimation of abundance and provides independent measurements to compare to abundances derived from gamma-ray and spectral reflectance techniques. (Narendranath, 2011, p. 54)

Multiwavelength astronomy formed the methodology of the scientific inquiry according to which the instrument C1XS was designed. However influencing its design was also a genealogy of other similar types of instrument. The scientist researcher Shyama Narendranath, in a paper published in *Icarus* (2011) detailing the research results of the mission, she presents the forerunners of C1XS (2011, p. 54), which includes the more idiosyncratic detail that C1XS was a redesign of an instrument that flew previously in the European Space Agency (ESA) Moon mission SMART-1. The instrument had not performed well on that mission, but by strengthening the mission team's expertise through the addition of scientists from ISRO, who had more knowledge in this area than the European scientists, a new proposal for the instrument was supported by ESA as a collaboratively managed experiment primarily between the Rutherford Appleton Laboratory (RAL) in the United Kingdom and a team at ISRO. Incorporating such forerunners, the process of designing the x-ray experiment C1XS followed an iterative rhythm of prototyping, testing, feedback and modification. Tests were designed to replicate the experiences the spacecraft was expected to encounter on its journey – from the intense vibrations of launch, to zero gravity, to the extreme temperature variations of the spacecraft between its sunlit and shadowed sides. These tests were a mixture of 'real' tests in which physical conditions of outer space were replicated as closely as possible, and mathematical, computer-based tests that modeled environmental conditions using predictive calculations, a mixture described by one of the mission scientists in this way:

> Some of it is real tests, some of it you have to say that the experiment that we have in hand is not exactly as it is going to be when it gets to space, it won't be the same a year after going around, [there's] a degradation, so you forward project the extent to which it will degrade. You have to convince that in spite of the degradation it will still work, so sometimes it's a combination where you use the calculations and the simulations. Sometimes you actually do a test – try to create all the dangers it will see on the way – and show in spite of that, and by using some clever analysis techniques, we can retrieve what we plan to do. (Interview by the author with P. Sreekumar, 2010)

During this stage, the spacecraft gradually takes shape through physical and computerised prototype models. From existing as a speculative idea, to a blueprint contained in a detailed written proposal, the spacecraft at this stage is distributed through physical and computational models and is to a large extent held cognitively amongst the instrument teams. In the arch of the spacecraft's life, which begins with the immaterial stages of anticipation and imagination, at this stage the spacecraft mission starts to congeal into materials. The future trajectory of the spacecraft's operational life is captured in choices of materials and shaped in its design through a process of recreating (or pre-creating) its anticipated experiences.

Here, the philosophical speculation mentioned previously by Guru and Sarukkai can be interjected to guide attention towards the propositions held within this prototyping stage. Looking at space technology through its processes of construction helps to remind that the visual separation of humans and technology is an illusion. But it is only when questions are asked as to how technology is *experienced* that the infused relation between humans and their technologies can be more fully recognised, imagined and superimposed back onto the materials and social processes of production. Through this experiential seam, it is possible to perceive the integrated relationships by which the biographies of the makers become inscribed into the biographies of the things they make. The discussion of the spacecraft in terms of experiences, opens the question of what experience itself can be said to be. The philosopher of science Sundar Sarukkai and the social critic Gopal Guru, in a book that has little to do with technology but addresses the morality of theorising about another's experience, have taken up this discussion. The central question of the book is whether the experience of a Dalit person can be theorised by a non-Dalit person. The book takes the form of a dialogue of essays between the two writers in which Guru asserts that the experience of a Dalit person is marked by the lack of freedom to make personal choices and that any interpretation from a non-Dalit will never access that essential condition, which is not translatable. From this position, Sarukkai then probes how experience may not belong to the experiencer entirely, by asking, "Is an individual the author of her experiences?" (Sarukkai, 2012, p. 38). He suggests two ways this could happen, one being if the experience is not of a person's choosing but of another's (2012, p. 38). In this case the experiencer may not feel himself or herself to be the author of the experience, as they would feel if they had chosen the experience themselves. Secondly, Sarukkai questions whether when we have experiences we fully realise them. In this way he questions how tenable the position taken by Guru is and opens a speculative position on the ownership and authorship of experience,

> We are related to our experiences as owners: we own our experiences but do not author them. It is perhaps similar to the way we own books that we do not author. Ownership confers a set of rights over what we own and authorship confers a set of rights over what we author [...] The extreme case of claiming that only those who experience can theorize implies that only an owner can be an author. Is this a tenable position? (Sarukkai, 2012, pp. 38-39)

This discussion of experience as something that can be owned and something that can be authored suggests that there is a bodily connection to experience that confers ownership, but also an imaginative connection to the experiences of others through which authorship can be claimed. Furthermore that one's own experience is not necessarily cognitively claimed, or articulated, unless it is in some sense authored, or given recognition, or synthesised, or voiced either outwardly, or even to the self.

While central to the discussion of the experience of a Dalit person is the morality of theorising about an experience that may not be accessible. What is central to discussing the role of the spacecraft in transposing, ultimately, an experience of outer space, is the central void of experience: the spacecraft is not a person, there is nothing at the location of the spacecraft that could be said to be having an experience.[74] In the light of the commentary given previously, the scientist said that during prototyping "you ... try to create all the dangers it will see on the way". The spacecraft's experiences are replicated, anticipated and in many ways it could be said the instrument teams also author these experiences during the prototyping stages: testing tells the story of the spacecraft's future experiences such as its degradation in the harsh ultraviolet light of space. The vacuum of space, the temperature fluctuations, the aging of the spacecraft, the changes in its ability to accurately measure are all simulated in the lab and via these actions are thought through and to some extent also experienced by the lab personnel.[75] Not all of the experiences of the spacecraft are thought through, noticed and cognitively or imaginatively marked by the same person. The whole of the spacecraft is experientially distributed across a population of personnel who each could be said to own fragments of this whole. Still though, the risks involved in making a spacecraft, the likelihood of damage or failure, indicates that this replication, empathy or understanding of the spacecraft's experience held within the space agency workforce, is far from complete. It would seem therefore, that there are experiences that the spacecraft has which are beyond prediction and not accounted for and that in some way only

[74] The accounts of astronauts in many ways give witness to many aspects of the spacecraft experience to which the scientist-makers do not have access. A good example of such accounts can be found in the book *We Seven* (1962) in which the seven astronauts involved in the Gemini missions describe in detail their training and flights in which they continually add information that the engineers have missed about the operation of the spacecraft.

[75] In Janet Vertesi's thesis (2009) titled *Seeing Like a Rover* she makes an in depth analysis of the relation of the Mars rovers Spirit and Opportunity to the mission team based at the NASA Jet Propulsion Laboratory. In her ethnographic account, scientists talk of being the rovers and of needing to feel and see like a rover. In this analysis the experience of connection to a space technology is extremely empathetic. Her evidence supports the argument being made here for the attachments between spacecraft and mission teams, although the connection to the spacecraft unlike the robot-like rovers is far less animated or immersive as an experience.

exist for the spacecraft. The limitations of the scientists to accurately replicate these experiences makes it clear that the spacecraft, in a way, does have its own experiences which are inaccessible to others. Without sentience such inaccessible experiences cannot exist, and yet they do exist to the extent that such liminal spaces of experience can be imagined. It is very possible to imagine the spacecraft having experiences. This intervenes in a similar kind of space articulated by Sarukkai when he proposes that there is a space within another's experience that can be shared, "In principle, we can theorize about another person's experience because there is a space within that experience that is not related to the experiencer" (Sarukkai, 2012. p. 39). There is a caution within the dialogue between Guru and Sarukkai not to do this, not to imagine or at least not to theorise an experience that is not one's own, however the will and ability to imagine is difficult to deny or contain. Types of experience, which can be imaginary, and are beyond what is necessary for the fabrication of the working spacecraft, form a surplus in the space agency workplace of a non-scientific, non-technical, more phenomenological seam of experiences and attachments.

To continue then to probe what kind of entity the spacecraft is by attending to types of experiences of the spacecraft held in the proximal zone of the space agency, after the prototyping work by the core team of ten to twelve scientists and researchers, the instrument then moves to a stage where specialists from outside the teams are called in. These specialists further test the team's work, applying the risk assessment criteria set by ISRO. As deadlines loom, certain decisions are taken about how much testing is necessary, and these decisions are made through joint meetings with collaborators often in other locations in India and overseas.[76] At a certain point the design is deemed to be good and the team has completed the prototype of their instrument, which is then handed over to the fabrication team in the assembly clean-room to construct the actual instrument that would 'fly' in the spacecraft. The spacecraft Chandrayaan, at this point can be understood as being an empty shell waiting for the installation of various experimental apparatuses, each designed by different teams, for different purposes, but needing

[76] See also Diane Vaughan's book (1996) that analyses the decision to launch the Challenger shuttle. Vaughan tenaciously follows the processes of risk assessment and decision-making through an ethnographic study of what took place and what was s said in the lead up to the launch. Furthermore she also traces how such decisions-making processes formed a shared culture within the space agency were also dependent on practices from the early days of spacefaring.

to operate collectively as a spacecraft and a mission. The 'spacecraft' and 'mission' become slightly different claims in which the spacecraft is an element of the mission, rather than its entirety. During this period of time when the actual spacecraft is constructed in the clean-room workshop, none of the core science and design team can touch the actual instrument that will fly, instead this work is carried out by the clean-room technicians. The work routine of the clean-room technicians has an altogether different rhythm than that of the experimental scientists. The core science team could be involved with the same instrument and spacecraft in different ways for a decade or more as designers and as part of the data analysis teams. The clean-room technicians, in contrast, could work on a large number of different satellites during the same period. One person for instance, might make 20 circuit boards, all of which would end up on board different spacecraft. During this time, the core instrument team loses some of their original autonomy over the instrument as the technical fabrication and procedural processes are handled in the main by the teams the clean-room assembly technicians.

In parallel to the actual assembly of Chandrayaan other teams worked on the tracking mechanisms by which the spacecraft could be remotely operated during its flight as well as the data management systems through which data acquired from the spacecraft could be downloaded, distributed back to the instrument scientist teams and also stored in a raft of bomb-proof hard drives. A new tracking station was built 30 kilometres south of Bengaluru at a village called Byalalu. The Indian Deep Space Network (IDSN) as it was named was constructed especially for the Chandrayaan mission.[77] Before this time all ISRO satellites had been in relatively close Earth orbit, but to track a satellite at the Moon required the construction of a 32-metre diameter antenna and a back up 18-metre span antenna. The operation of the facility in terms of creating a computer system by which data would be acquired, distributed and stored was built and managed by a small team of scientists, computer programmers, engineers and technicians. Their work on Chandrayaan started about a year before the launch when they began to work at the Byalalu site. An aspect of their work involved negotiating with the local

[77] The Indian Deep Space Network (IDSN) also has the capacity to track at distances ten times those of the Moon and was built in anticipation of deep space missions to Mars and elsewere (Ramachandran, 2008).

village, Byalalu, for use of the site. In return for using local agricultural land, ISRO provided a new road and jobs for local people.[78] In these early days they would sometimes need police escorts to take them to their place of work as negotiations for use of the land caused hostile reactions from the village community. In the last few weeks leading up to the launch, the data acquisition systems team slept on site working in shifts to complete on time. Byalalu tracking station was also given its requisite inauguration with a *puja* blessing involving priests and ISRO Directors and began its working life with the launch on 22 October 2008 of the Chandrayaan spacecraft.[79] Each time the Moon appeared on the horizon, during the life of the spacecraft, the 32-metre dish would revolve and lower to lock onto the rising Moon and the spacecraft, following both through the sky daily, uploading and downloading data.

A crucial part of the data system design was to calibrate each instrument that would fly in the spacecraft with the data management system. The instrument teams needed to personally visit the Deep Space Network tracking station at Byalalu in order to see that the data acquisition systems worked in tandem with each instrument. Calibration takes account of known 'mistakes' within the design of the instrument that would affect measurements and so these 'mistakes' are factored into the acquisition systems as far as possible in order to give the most accurate readings. Calibration is a complicated and intriguing aspect to instrument design because the knowledge of the real instrument, as opposed to a theoretical/mathematical model, is full of refined nuance much of which inevitably becomes held as tacit knowledge by the experiment scientists themselves. Their tacit knowledge is gleaned from the experience over a long duration of testing, designing and building their own instruments. The Principal Investigator for one of the instruments traveled from the United States to spend three weeks at the Byalalu site working personally with the system technicians to ensure that these non-transferable, but crucial forms of

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[78] The cultural archaeologist Alice Gorman considers the cultural heritage of a launch site in Woomera, Australia and notes with some irony how those living near to space installations "face a range of impacts from dispossession to recruitment" (2007, p. 155). She signals a pattern in the negotiations of space agencies with their localities in which supposedly fair negotiations are inevitably extremely biased towards the space agency, which inevitably holds more negotiating power. Cultural geographer Peter Redfield (2000) finds a similar pattern at the ESA launch site in Kourou in French Guiana, where local residents were similarly offered a new road.

[79] Puja is a blessing associated with Hindu faith. When I visited Byalalu tracking station (Indian Deep Space Network IDSN) there were photos inside the 32 metre antenna building of the inauguration event.

tacit knowledge could be accounted for in the calibration process.[80] Calibration, like the iterative processes of prototyping, contains elusive but important keys to the detailed, interpretive and intuitive qualities of technology and engineering.[81] As aspects of the calibration adjustments are input into computer data systems, other aspects that are beyond translation remain with the mission teams and are used in the long process of interpretation of the instrument results.

The most publically iconic moment of a spacecraft's life is its launch and a celebration of achievement. For the mission teams there are also a number of less publically accessible moments that can have more import. The Director of ISRO's tracking wing, ISTRAC in his account of the Chandrayaan's launch (Shivakumar, 2010) cited the reception of the spacecraft's

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[80] The inclusion of US scientists in the Chandrayaan mission reflects significant shifts in US-India relations following agreements made between the two countries since 2004. These shifts are significant when compared to the non-aligned position of India taken by Nehru in the 1950s and 60s that so enraged the US administration (as descibed in Chapter 1) and the economic sanctions imposed on India by President Clinton immediately following the nuclear tests at Pokhran in 1998. In an interview with NASA Adminstrator Michael Griffin journalist Pavla Bagla alludes to the dependency of the scientific collaboration on higher level international relations between India and the US: "*The scientist to scientist collaboration seemed to have worked wonders, but at the level of government, you almost missed the ride*" (Bagla and Menon, 2008, p. 159, italics in original). Significantly to this process, India and the US signed the Civil Nuclear Agreement on 10 October 2008 (just days before the launch of Chandrayaan on 22 October) after a three-year negotiation process that began in 2005. ISRO put out an international call for payloads to join Chandrayaan in 2004 and a joint India-United States Conference on Space Science, Applications and Commerce took place in June 2004. The meeting was significant because after India's nuclear tests in 1998 there had not been a meeting between scientists from Indian and the United States (Bagla and Menon, 2009, p. 103). The imposed economic sanctions on India included an "entities list" of over 40 companies that would not be allowed technology imports and this list included ISRO and the government Defence Research and Development Organisation (DRDO), The involvement of US teams on Chandrayaan (the Moon Mineralogy Mapper instrument led by Carle Pieters and the Mini-SAR led by Paul Spudis) was agreed in 2006 and can be related to parallel developments in trade and other agreements whereby sanctions were gradually lifted. These include the Weapons of Mass Destruction and their Delivery Systems (Prohibition of Unlawful Activities) Act of 2005, known as the Weapons of Mass Destruction (WMD) Act; the Henry J. Hyde US-India Peaceful Atomic Cooperation Act in 2006 and the non-government Indo-US Science and Technology Forum which began in 2000 and provided a mechanism for meetings around science and technology to resume between the countries, which were also vehicles for revisiting and reviewing existing sanctions. However, ISRO was only removed from the "entities list" in 2011 following President Obama's visit to India that brought another stage in strengthening relations.

[81] The "non-scientific and non-literary" aspects of engineering and technology making that Eugene Ferguson refers to are also relevant here. His analysis (1977) used evidence of the pictorial language of engineering, such as found in Diderot's *Encyclopedie* that consisted almost entirely of engravings of different kinds of technological machines during the time 1751-1780. Ferguson emphasises the visual thinking involved in engineering design in attempting to account for the intuitive and distinctive qualities of thinking involved in engineering design. Walter G. Vincenti attempts a similar explication in the book *What Engineers Know and How They Know It: analytical studies of aeronautical history* (1990) which builds on related work by Edwin Layton and John Staudenmaier that emphasises the ways that technological form is evidence of thought and for which it provides a trace. The literary writer Paul Carter (2004) has developed a theory of 'material thinking' through reflective study of his own collaborations with artists. His theoretical perspective that is drawn from practice could also be referenced here to further interrogate the interfaces of making processes. His phrase "material thinking" would be usefully brought to bear on existing discussions of engineering thinking.

signal from the Moon on 5 November 2008 as the defining moment of success. One hundred days after the launch, all the scientists from the Indian and international teams met to compare data and findings so far and to mark the success of the instrument's and the acquisition of new data. Other celebrations include 14 November, Children's Day, when the impact probe stamped with an Indian flag crashed into the Moon surface. Chandrayaan orbited the Moon at a distance of between 100 and 200 km during its working life until after just over a year of its planned two-year mission contact was lost with the spacecraft. The spacecraft's whereabouts are currently unknown but it is expected that through the gradual decay of its orbit it would by now have fallen onto the Moon. On 25 September 2009 the front pages of the newspapers in Bengaluru ran the headline that Chandrayaan had found water on the Moon.[82]

This sketch of the involvement of different personnel at ISRO and elsewhere on the Chandrayaan mission is far from complete, but gives some sense of the locations, types of work and different longevities and starting points across the workforce. In general, the technical engineers work for three to four years on the spacecraft assembly. Their work can finish more or less with the launch, at which point a different kind of system engineering begins that is based at the mission control and tracking stations. Scientists work to a different timescale developing the experiment and analysing the data before, during and after the life of the spacecraft. Other researchers may also use data from spacecraft, which generally becomes released outside of the instrument teams one year after it is acquired. These scientists may have little knowledge of the actual spacecraft. Although online data archives usually contain text files concerning calibration issues, sometimes the lack of detailed knowledge of an instrument is a problem for doing this kind of secondary sourced research and is the reason why science teams like to make their own instruments. Many scientists working with data from satellites though are unconcerned about the spacecraft itself, its reality impinging little on their research questions.[83] Others find that they and their research are embroiled with the spacecraft and that individual spacecraft have

[82] The Principal Investigator Carle Pieters of the NASA funded M^3 team (Moon Mineralogy Mapper) announced that their instrument on board Chandrayaan had confirmed the presence of water ice at the lunar pole in a paper appearing in Science magazine on 23 September 2009 (Pieters, 2009).
[83] See commentary in Preface about some difficulties in talking about the space technology with space scientists.

deep personal significance, as discussed in the Preface.[84] The C1XS mission teams highlighted two main sources of attachment. One source was the making of the X-ray instrument and the satisfaction generated through the crafting of a unique and refined instrument that performed extremely well. The other source of attachment was with the team members who had worked so hard together on a joint effort to produce the instrument through an intense collaborative effort and flow of minds. Attachments such as these can be understood in part as the product of the emotional energy involved in making such fragile and complex projects over a long period of time and the intellectual investment this represents, through which strong personal bonds develop. These bonds reflect far more than familiarity, they are richly constituted through collaborative thinking. Making, problem solving, shared endeavour, shared intellect and team reliance occupy and constitute the material processes of the design and fabrication of the spacecraft. Its only by going closer into the relation between the makers and the technology, by looking for the blurring in which the makers are configuring themselves to the technology as well as configuring the technology to themselves, that deeper levels of continuity between what is made and what is used can become apparent. Space technology production at this proximal zone is visibly and palpably entwined with people. To follow the narrative as it has been laid out here is to notice the spacecraft and its infrastructure visibly emerge from the minds of women and men.

At launch that formational entwining becomes graphically broken. The distributed, shared spacecraft in the moment of launch appears to disconnect and in its propulsion away from the earth, the spacecraft acquires a substantially alternative identity. The spacecraft in space acquires wholeness, completeness and an identity almost that of a 'personage'[85] that perhaps it lacked throughout its fabrication stages. The spacecraft acquires an identity that is a hybrid of its entangled relation to the production teams and a less explicable independent character of sorts by which the spacecraft body – the named entity Chandrayaan – becomes a site of

[84] See also the commentary in the Preface referring to attachments to spacecraft revealed during conversations at the Space Science Lab in Berkeley about lost spacecraft.
[85] The sculptor Louise Nevelson used the term "personage" in titles for her abstract sculptural works made of re-appropriated material that had the presence of a person. The assemblage-like structure of the spacecraft, though not elongated like standing people as her sculptures were has many correspondences with the idea of personification suggested here.

meaning beyond that of the scientific experiment.[86] This class of experiences could be related to a new capability of the spacecraft itself to author, or enable authorship, at the locus of its own central void of experience. The fullness of the meaning of the Sanskrit name Chandrayaan is probably only apparent to those with knowledge of the Indian languages for which *chandra* is understood as Moon and *chandrayaan* as a Moon chariot, evoking the carriages of gods. In the naming of the spacecraft an identity of sorts is formed and perhaps a capacity to author.[87] Through the act of launch in which the spacecraft spectacularly separates not only from its makers, but also the Earth, unavoidably, the spacecraft assumes an independent aspect bringing a new perspective into view and camouflaging the huge technological and human infrastructure of which it is just a fragment. The merging of the spacecraft with its makers that has been

[86] As mentioned previously, Janet Vertesi (2009) suggests similar entanglements in her study of the relation between the Mars rovers and their Earth-based human operators. A sense of this entanglement is much more traceable through human spaceflight. In the book *We Seven* (Carpenter et al., 1962) for instance, the seven US Gemini astronauts talk through their pre-flight training and along the way describe in great detail their role along with the engineers in the design process. See for instance John Glenn's comment about climbing into the Mercury spacecraft, "You squeeze past all the gear that is mounted inside, like a man sliding under a bed. Once inside, you almost feel like just one more piece of equipment – the most important piece, of course." (Carpenter et al., 1962, p. 104).

[87] In the broad field of research into material culture including technologies, the application of human attributes, particularly of agencies to non-human objects has been pursued for instance in Bruno Latour's formualtion of the 'actant' and Donna Haraway's 'cyborg'. In the *Handbook of Material Culture (*Tilley et al., 2006), an essay titled 'Agency, Biography and Objects' (2006) by Janet Hoskins draws attention to literature that uses a biographical method and analogy for understanding non-human entities. Her commentary cites authors such as Arjun Appadurai, *The Social Life of Things: Commodities in cultural persective* (1986) whose approaches to objects that pass from hand to hand through commercial or other kinds of valuing reveal the object as a negative trace of complex social processes (p. 75). Also Igor Kopytoff , 'The cultural biography of things' (1986) and Alfred Gell, *Art and Agency: An anthropological theory* (1998). From her synthesis of this body of theory, three key insights can be gleaned through which the biographical inscription of objects can be tracked: (1) the intentionality of objects given by their creators; (2) the shifting identities of objects for different groups of owners or users; (3) the active role of objects in providing opportunity for human agency in the world. She writes: "Material objects thus embody complex intentionalities and mediate social agency", (2006, p. 75). The biographical analogy centres agency on the spacecraft as an object with a name, with the singularity even of a 'personage'. A reading in the opposite direction so-to-speak of the spacecraft as a decentred entity, shifts the agency of the spacecraft to a distributed field of human agents through its technological and human infrastructure. Both readings can be thought of as two sides of the same coin, as readings of the same entity as both singular and distributed in a "recursive relationship" (Tilley et al., 2006, p. 4). Hoskins refers to this mediation of human agency via objects as an "agential turn" (2006, p. 74), meaning that objects in effect seem to have agency, like humans, to make things happen in the world. In the case of the spacecraft, because of its sophistication as a machine/computer, and because it can go to places humans cannot easily reach, it can seem that the spacecraft, more than the human creators, is implicated in the events it encounters and is the location of experiences. This imaginary of machine agency is carried much further in fictions of robots achieving sentience such as the HAL computer in *2001: A Space Odyssey*, or the other cyborg mutations that form the plot devices of films such as *The Stepford Wives*, or *Robocop*. This merging of human and machine is the "cyborg myth" unpacked in Donna Haraway's 'A Cyborg Manifesto' (1991). These are extreme examples of a much more low-level suggestion of autonomy or agency that can be felt to be an underlying imaginary of the spacecraft.

carefully delineated, conflicts with this visible separation, by which the spacecraft appears to acquire its own agency.

It could be said that a new class of experience began from launch, authored in some way through the production of the spacecraft and its dual identity as both a technologically entangled and imaginatively independent entity. One director for instance spoke of the Moon being different for them now that their spacecraft was there. The detachment and acquisition of an identity as a whole object led to another set of more phenomenological associations of the spacecraft. These associations or experiences or sensibilities posed problems – they were not easy to indentify or feel with certainty, or in the phrase of Sarukkai, to author. At Byalalu tracking station it was possible to stand outside and see the huge antenna point at the spacecraft and at the Moon and then walk inside to the mission control room and see the streaming video of the surface of the Moon appear live, directly from the spacecraft and directly from the Moon. At night time, this was an especially privileged experience, particularly as the tracking station was in a less populated, semi-rural area and set within a perimeter wall enclosing a large area of open landscape from where the sense of closeness to the Moon felt palpable. During the night shift, the Moon could be seen in the night sky together with images taken at 100 km from the Moon's surface almost at the same time. The scientist at Byalalu could stand outside and see the white Moon against black sky, not only that, but stand next to a huge antenna dish pointed at the Moon and moving in line with its precession across the sky. Then moving inside she or he could watch the Moon surface displayed on large screens in the cavernous mission control room. In addition, the visual veracity of seeing the images of the Moon surface and the technology producing the live broadcast would have been supplemented by the scientist's involvement in the crafting of the technological system. The experience should, in many ways, have given this viewer a profound sense of closeness with the Moon, one of the most prized experiences of humans. It should perhaps have been a sublime experience. However, in discussing the special relation at the Byalalu site between the viewer, the technological structure, the Moon and the live televisual stream, the operations team understood the privilege of this encounter and valued it, but were struck also by its banality. The specialness was peculiarly difficult to experience.

There was a sense that in many ways an outsider might experience it better, that the operations team's closeness might have made this lunar connection routine for them and that somehow knowing more equated with feeling less. Perhaps one of the reasons for this shortfall in an expected experience was that the images on the screens did not look or feel like they came from the Moon, raising the comment from one of the team, "see people say that the poet likes the Moon because it is very beautiful, but when you see those pictures, it is not beautiful" (interview with the author, 2010). The images looked like computer-generated images of the kind seen in virtual reality games. They were pre-processed stereoscopic images and therefore appeared slightly greyed-out, and with a slight skew as if the wrong aspect ratio had been chosen for the display screen. The Moon in the sky, seen with the naked eye, was not like this disappointing projected image in any way but full of contrast, the brightest visible form against the darkest sky. Moreover, the Moon outside, seen from the ground could be watched while breathing in the night air, a 'seeing' that ineluctably blended viewer and environment.

Summary

From the theoretical perspectives introduced at the beginning of this chapter, the emphasis given to usership and establishing the social construction of technology can be extended substantially to encompass experience. It can now be suggested that the qualities of experience identified through this chapter enrich these theoretical positions, modified through ambivalent notions of ownership and the interventionist claims of authorship, which have a strong relation to the dimension of the imagination and the potency by which the spacecraft body suggests independent agency. This dimension to the authoring of experience that is imagination, gives imagination a crucial place within the technological construct. The profound affiliation of the imaginary with the technological finds a more poetic and nuanced realm of discourse within studies of material culture. The discourse of material culture provides a substantial platform from which to engage with the nuance of such kinds of reflexive relations between artifacts and bodies.

In considering Chandrayaan as a technography and in relation to the notions of experience, ownership and authorship there appear to be gaps and discontinuities. It will be argued that these gaps and discontinuities between these abilities to experience, own and author have a direct bearing on the artistic intervention that will be described in Chapter 4 and the close alliance formed between the artists and scientist-makers. In the next chapter the public-facing representation of Chandrayaan will be considered in more detail. The thesis will then argue that that close alliance between the artists and scientists resisted the public version of events because that version by-passed or did not sufficiently accommodate the viewpoint or version of the spacecraft held by the scientist-makers in this proximal zone. If the scientist-makers share experiences with the spacecraft, but the location of the experience is a void, then this space can be potentially transferred and co-owned. The central void of experience, located at the spacecraft is accounted for by imagination. A shared imagination. The sharing of spaces of experience, authorship, ownership, imagination, technical and scientific that space technology gives rise to is examined in the next chapter in relation to the state.

Chapter 3

The public-facing presentation of the spacecraft

This chapter forms the second part of a technography of the spacecraft. In the previous chapter the spacecraft was considered from the perspective of the scientist-makers designing and working in close proximity with Chandrayaan. This chapter first traces the presentation of Chandrayaan in the public domain, noticing the close alliance of the spacecraft's public presentation with agendas of the state. Secondly it unfolds the less evident origins of the spacecraft to the ideological, political and technological climate around the year 1999, when the proposal for the spacecraft began to be made public. In this chapter the ideological contract between the Indian state and the spacecraft Chandrayaan is broadly addressed. This is done in two ways: by contextualising the meanings given to Chandrayaan which are accessible in the public realm and by tracing the relation of these meanings to their sources within shifting and evolving technological, scientific and national imaginaries. A pattern emerges by which the values assigned to the spacecraft in the space agency production workshops become displaced with other imaginaries once they enter the public realm. One way this displacement can be understood is through the theoretical perspective of the fetishisation of technology as used by Itty Abraham in his study of nuclear technology in India (Abraham, 1999).

To continue some of the themes of authorship and ownership from the previous chapter, the argument proposed in this chapter is that through the fetishisation of space technology, the state commandeers its ownership of the spacecraft. The state's ownership of rockets and spacecraft is enabled through acts of authorship that take the form of a mediating commentary and imagery, which intervenes into the imaginary of the spacecraft, using the many facets of public-facing representation. The moves of the state to create a public-facing image of the spacecraft dissolve originating experience (the social processes that produced the technology presented in the previous chapter) in order to purloin or supplement the meaning-making capability of the technology. Exploring the mechanisms of this process reveals how use can be made of the spacecraft beyond the scientific and technical workplaces of its production, operation and data analysis.

The significance of the spacecraft Chandrayaan, launched in 2008, reaches far beyond the workplaces of its production, outlined in the previous chapter. The concern of this chapter is the way that the spacecraft is presented outside of the proximal zone of the space agency. The evidence and interpretations given in this chapter continue the technography further afield to continue to trace an affective space of the spacecraft. It is moments of the spacecraft's public appearance, as image, commentary, information, learning tool, or otherwise that constitute what kind of entity the spacecraft becomes beyond the proximal zone of the space agency. To build this part of the technography, instances of the public appearance of the spacecraft and the sources of its representation will first be presented.

What is argued in this chapter is that through the public-facing representation of Chandrayaan an intervention is made, primarily by the state, to claim the spacecraft and shape its meaning. It is argued that this happens in ways that significantly camouflage the agency, authorship and experiences of the scientist-makers and at the same time strongly suggest how the spacecraft should be thought about, received, used and thereby experienced in the public realm. The meanings given to Chandrayaan that are accessible in the public realm have a strong relation to technological, scientific and national imaginaries. In the second part of the chapter the sources of these imaginaries and their relation to the emergence of the idea to launch a mission to the Moon, are traced so that the ideological contract between the Indian state and the spacecraft becomes more transparent. The purpose of this move within the thesis is to build a picture of the set of forces and influences that led up to and were present at the time of the artist-led interaction that is introduced in Chapter 4.

At the outset it should be made clear how the Indian space agency is organised as part of state governance. The Indian Space Research Organisation (ISRO), that began as an almost hobbyist wing of the Department of Atomic Energy soon after, under the Chairmanship of Sarabhai's successor Satish Dhawan became ISRO, the operations wing of a new Department of Space which like the Department of Atomic Energy sits within the government Ministry of Science and Technology. The organisational structure is given in the diagram below.

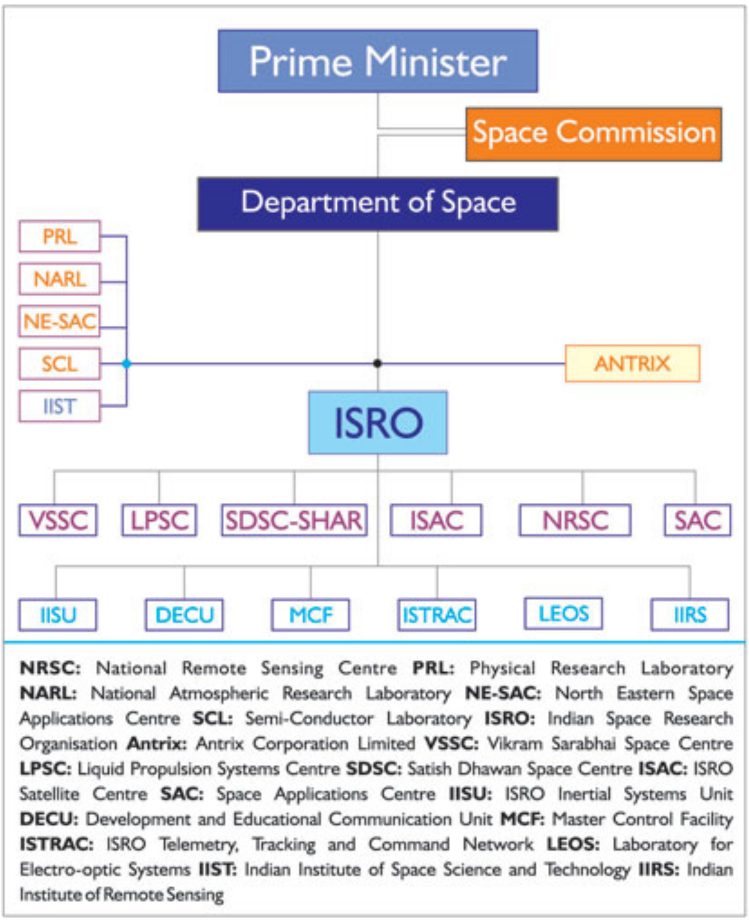

Figure 11: Organisational diagram of ISRO showing its relation to the government (Indian Space Research Organisation, 2008a)

The diagram can be found on ISRO's Website with the following explanation:

> The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS [Department of Space] implements these programmes through, mainly Indian Space Research Organisation (ISRO), Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL). The Antrix Corporation, markets the space products and services. (Indian Space Research Organisation, 2008b)

Publications by ISRO and commentary by ISRO officials can therefore be understood as part of a state discourse.

State is a loaded term that has figured in discourse most notably in the writings of Louis Althusser whose category of 'Ideological State Apparatuses" addresses the structuring of state derived ideologies into the apparatuses of institutions and technologies such as schools, hospitals, religion, law, family life and communications media (Althusser, 1969). The discussion of this chapter though is not around meanings of state apparatus and state power. The term 'state' is used more as a term of convenience that moves the focus of the thesis onto the haphazard and contingent processes by which the spacecraft is made visible and accountable within the public domain. Considered in this chapter are sources of the spacecraft's public presentation and its mediation by statespersons, bureaucrats and officials of many kinds through newspapers, television, public appearances and exhibitions. The idea of state used here is the informal relationship between government, public media and citizen. Through a comparison of the findings of this chapter with the findings presented in the previous and next chapters attention is drawn to ways in which the purview of state falls short in two crucial ways: First by dissolving the viewpoint of the scientist-makers and secondly by imposing an account of the public viewpoint that does not correspond with a vernacular experience.

Theoretical perspectives: fetishisation and spectacle

The theoretical concept of the fetishisation[88] of technology is used in this chapter to guide the central propositions of the argument. This concept is tied to the visual spectacle of state

[88] The idea of the 'fetish' has been taken in many ways through discourse. Marx uses the concept of 'commodity fetishism' (as also have Walter Benjamin and Theodor Adorno), which is the thread adopted by Abraham here. Fetishism, as developed in the work of psychoanalysts Sigmund Freud and Jacques Lacan led to other divergent applications of the concept. In an essay by William Pietz in the anthology *Fetishism as Cultural Discourse* about Marx and materialism, he comments on a link between fetishism and ideology, referencing Althusser's "appropriation" of the fetish as developed by Lacan as, "the fetish as the ideological object itself" (1993, p. 125). Interestingly for the argument of this thesis Pietz indicates how this formulation of the fetish compensates for an inability to experience something conceptual or too large (such as capital) and he uses the example of the image of the Whole Earth, "since the larger historical and social world in which we live can never, as such, become an object of direct experience for individuals, we substitute for this unexperienceable and unrepresentable reality an imaginary

technologies as representations by which ideologies and imaginaries become visibly evident and influential. Fetishisation helps explain dislocation of meaning from object. In the case of the spacecraft a re-assignment of its meaning takes place in the passage from production workshop to public realm. Itty Abraham provides some astute insights as to how such processes happen in relation to nuclear technology. Abraham looks at processes of diverting meaning or replacing meaning which he calls the state fetishisation of technology. He explores how interventions were made into the imaginary of nuclear technology by the Indian state over the same time period that space technologies were developed. His reflection on the use by the Indian state of the nuclear bomb in his book *The Making of the Indian Atomic Bomb: Science, secrecy and the postcolonial state* (1999), considers how visible technology was in some ways used to instill change in the population. He recalls that written into the Indian constitution are the duties of citizens, one of which is the duty to inculcate the "scientific temper" (Basu, 1998).[89] Abraham argues that the state lacked the means to get inside the people and bring the modernising change it desired. The change that the state sought to bring about in the general population was a change from the spiritual to the secular, such as exemplified within scientific practices and championed by the first Prime Minister of India, Jawaharlal Nehru. However Abraham writes that the state's thwarted attempts to bring about such a change are evident in the building of

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representation of our relation to history and society-a picture of the "Whole Earth," say" (p. 125). Michael Taussig in the same volume develops the idea of "State fetishism" in which he tries to understand a certain mysticism of state that is produced, again, because the state itself is hard to see or interrogate. It seems knowable only from a distance and to lose its substantial qualities close-to (1993, p. 218).

Like Abraham, Joseph Masco (2006) also uses the concept of 'commodity fetishisation' to unpack nuclear technology as a "national fetish". In Raminder Kaur's book (2003) about vernacular religious/political displays made for Ganapati festivals in Mumbai that contain complex imagery of gods, politicians and celebrities as well as nuclear and space technology, she draws on Taussig to unpack the iconography of nuclear technology (in Chapter 7) used in these displays. Here a relation to actual nuclear technology is revealed that divulges a fetish-like relation between publics and technologies they are distanced from, "Such measured yet tantalizing exposure of nuclear icons contributes to creating sanctity for the object. A certain degree of 'unmasking' in a 'drama of revelation' reveals a 'public secret'– something that is generally known but cannot be articulated" (2003, p. 192).

[89] A topic that caused lengthy discussion in the 1980s led by Ashis Nandy, Vadana Shiva and others around the Centre for The Study of Developing Societies in Delhi, as reported on (with much disdain) in Meera Nanda's chapter 'The Battle for Scientific Temper in India's New Social Movements' (Nanda, 2004). Debate was sparked by an article in *Mainstream* magazine in July 1981 'A Statement on Scientific Temper' (Bhaduri et al., 1981) by a group from the Nehru Centre in Mumbai (then Bombay) which ends with the words, "Our nation's survival and its future depends on upholding Scientific Temper. Superstition shall not pass and darken our portals" (Bhaduri et al., 1981, p. 10). In October Ashis Nandy published a 'Counter-Statement on Humanistic Temper' (Nandy 1981; 1982). The phrase 'scientific temper' has a far broader usage to motivate rationality through social movements such as the People's Science Movement and can be situated as part of a state discourse advocating the adoption of technologies.

massive technology. The state was socialist, not totalitarian, it could not force its will on the people, but:

> What the state could do was install massive, modern, awesome technological artefacts – dams, steel mills, new cities, nuclear reactors – objects embodying a different rationality, which would transform traditional landscapes through their sheer power; the hope was that the technological artifact would stand in relation to the people as a modern *fetish*. (Abraham, 1999 p. 20 — emphasis in the original)

The concept of fetishisation refers to a disjuncture between referent and meaning. For Abraham it is "a ruse to distract the eye and the mind from something that needs to be covered up" (1999, p. 156). For instance, what he suggests is that the state wants its citizens to become scientifically minded, but the state itself cannot bring about that change, it cannot control the minds of the people. What it can control is "megatechnologies". Large-scale technologies, in Abraham's argument, are used as a fetish by the state to stand in for the scientific temper or secular worldview or modern outlook that the state wishes will appear in its population. Fetishism is a type of intervention into the imaginary of a technology made by creating a focus to distract the eye, which simultaneously draws into shadow certain other constituent parts of the entity.

Karl Marx used the concept of the "commodity fetishism" (Marx, 1867) to indicate the separation between monetary value and use value to explain the way that commodities can be exchanged for money or for their use. Significantly, Marx also used the concept of fetishisation to indicate how producers are separated from the use of the commodities they produce – a linen factory worker is not necessarily going to wear what they make. In the case of the spacecraft however, as shown in the previous chapter, those factory conditions do not so easily apply in part because a unique object is being made and in part because the bespoke users are so enmeshed in the production stage: The experimental scientist is both producer and user.[90] However, the characteristics of fetishisation – the separation of the object from its producers –

[90] Many of those employed in the space agency are not so closely connected to the use of the spacecraft as the core mission teams. For instance many of the electronics engineers, as well as administration staff who I encountered at ISRO, at the Space Science Lab in the University of California, Berkeley and in the Mullard Space Science Lab in the UK (see Preface) did not feel that they were closely connected with spacecraft. Many of the factory working conditions identified by Marx do apply in some ways to the space agency workplace but the workforce is also unusual in that it includes bespoke users.

can be discerned in the passage of the spacecraft to a wider public realm such that in the public-facing representation of the spacecraft a separation of the object spacecraft from its makers *is* effected: The original meaning of the spacecraft, or its meaning for the scientist-maker, is to some extent, erased and replaced.

As recognised by Guy Debord, Marx's theory of capital could be visualised in the overwhelming spectacle of products and consumption present in street life and the everyday experiences of living in capitalist societies. In *Society of the Spectacle* (1967) Debord puts forward a manifesto that makes the visual central to capital and the social processes capital produces through relations of state, apparatuses, commodities, technologies and citizens, "Capital is no longer the invisible centre which directs the mode of production: its accumulation spreads it all the way to the periphery in the form of tangible objects. The entire expanse of society is its portrait" (Debord, 1969, 1983, section 50). So too, the forms of visible representation by which the absent spacecraft is represented in the public realm becomes both a heuristic by which to interpret state messages and a medium by which to construct new imaginaries. In a discussion about representation by the visual culture theorist W.J.T. Mitchell he refers to the "triangular relationship" whereby, "representation is always *of* something or someone, *by* something or someone, *to* someone" (Mitchell, 1990, p. 12). Following this proposition, representations of Chandrayaan could thereby be used to trace how one constituency thought the spacecraft should be presented to another constituency. The production of imagery and commentary around Chandrayaan is an intermediary material constructing in certain ways not only Chandrayaan but its public audience and the image of the nation-state. In certain ways representations and commentaries tell the recipient – the audience, the public, the citizen – who they should be in relation to the spacecraft, how and if they should be using the spacecraft and how they should think about it. The production of commentary and representation not only of Chandrayaan, but also of space technology in general is full of such indicators of use and usefulness and interpretation. This provision can require little or no additional input leaving the recipient with only superficial forms of engagement such as taking photographs of themselves next to models of spacecraft in museums. Photography, when allowed in such situations becomes a substitute for a more meaningful connection, or in some ways it becomes the only meaningful connection or use available and allowed by the public of space technology. Such limited interaction appears to inadequately reflect the pact that exists between the space programme and its societal remit or even its goals for the human species. There is a delimited space for participation structured into representations of the spacecraft that posit modalities of reception that determine how space technologies should be understood and used in the public domain.

In summary, the concept of state fetish, as used by Abraham in his study of the Indian atomic bomb, which draws on the work of Marx, highlights a number of tendencies that can be used to analyse characteristics of the spacecraft Chandrayaan in its passage to outer space and to the public realm. These characteristics follow the logic of the fetish in which there is disjuncture between referent and meaning and a space for interference. This includes a disjuncture between scientist-makers and the spacecraft entity, a haphazard or inexact process of purloining the meaning of large-scale technology, inconsistencies in political aims, the ineluctable attraction of the visual spectacular produced by space technology and a strong link to the formation of national imaginaries. This process is now enlarged on through an examination of types of public-facing presentation of Chandrayaan through which another set of meanings can be extrapolated. These meanings, which are related to scientific, technological and national imaginaries, are produced through processes of intervention, re-appropriation and replacement of meanings whereby through the fetishisation of the scientific instrument it is transformed into an instrument of state.

The public-facing presentation of Chandrayaan

In this section sources from publications together with other public commentaries and exhibits are considered to see how the spacecraft has been presented. This builds a picture of its anticipated uses, users and meanings while also making transparent from where and from whom this picture of the purpose of the spacecraft originates. In continuing the technography from

Chapter 2 where it was seen how scientist-makers configure the instruments on the spacecraft to answer scientific questions, here, the processes of configuration change. Users in the public domain appear to be configured towards the spacecraft, rather than configuring it. In terms of the 'certainty trough' introduced in the previous chapter, it is in the public domain that certainties about the spacecraft technology appear to be beyond doubt.

i. Publications and commentary

According to the book *Destination Moon* (Bagla and Menon, 2008) published by ISRO, the beginning of Chandrayaan is located in a speech given by the then Chairman of ISRO, Kasturirangan, on 11 May 1999. One of the book's co-writers, the journalist Pavla Bagla was present at this speech which was given to mark the recently nominated national day called Technology Day. Bagla's commentary goes as follows:

> Towards the end of his hour-long talk, Kasturirangan, without fanfare and with a serenity that only he could display while making such a historic announcement, gently slipped in a seemingly unremarkable comment - that the PSLV [Polar Satellite Launch Vehicle] could undertake a mission to the moon. (Bagla and Menon, 2008, p. 82)

Destination Moon is the only substantial publication about the Chandrayaan mission, telling the story through key figures such as ISRO Directors and thereby revealing the process of the spacecraft's making.[91] The book begins with a foreword by former ISRO Chairman Kasturirangan and is followed by a foreword by the then current ISRO Chairman Madhavan Nair, so establishing the book's authority as sanctioned by ISRO itself. In this book the mission of Chandrayaan is stated in the following certain terms, "The overarching mandate of the mission is quite unambiguous" and this is followed with the brief explanation, "to expand the country's scientific knowledge about the moon, and contribute to the world's pool of knowledge that can then translate into advancement for humankind" (Bagla and Menon, 2008, p. 91). Although a link is made here between the mission and the advancement of the human species, on ISRO's Website the rationale is more pared down referencing only the mission and no other

[91] There are several smaller books about the Chandrayaan mission (Datta and Chakravarty, 2008; Bhandari, 2008; Basu, 2009; Guruprasad, 2009; Bansal, 2010; Das, 2010).

cultural context. The ISRO Website states Chandrayaan's objectives, giving the following two "science objectives":

- To prepare a three-dimensional atlas of both near and far side of the moon.
- To conduct chemical and mineralogical mapping of the entire lunar surface for distribution of mineral and chemical elements such as Magnesium, Aluminum, Silicon, Calcium, Iron and Titanium as well as high atomic number elements such as Radon, Uranium & Thorium with high spatial resolution.[92]

Two "mission objectives" are then given:

- To realise the mission goal of harnessing the science payloads, lunar craft and the launch vehicle with suitable ground support systems including Deep Space Network (DSN) station.
- To realise the integration and testing, launching and achieving lunar polar orbit of about 100 km, in-orbit operation of experiments, communication/ telecommand, telemetry data reception, quick look data and archival for scientific utilisation by scientists. (Indian Space Research Organisation, 2008c)

The science objectives are concerned with mapping mineral deposits. These summary objectives can be traced to the work of the Lunar Task Force set up to build a scientific rationale for the mission and the published papers of Narendra Bhandari, a planetary scientist who had studied lunar samples given to India in the 1970s. The mission objectives concern technology rather than science and address the technological capability of the mission – the capability to organise, build and operate a spacecraft at the distance of the Moon primarily through developing new ground-based infrastructures. The mission required the building of the Deep Space Network that includes two large dish antennas and a state-of-the-art data management system, including a bomb-proof archival data storage facility.

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[92] The formulation of the scientific objectives of the mission can be traced to scientific papers. Objectives were formulated initially in a paper published in Current Science in 2002 by the planetary scientist Narendra Bhandari. Bhandari analysed lunar material samples from the Apollo missions and began publising papers on his findings in 1971. His papers can be accessed at this site http://www.nbhandari.com/nbhandari_com/NBhandari/index.aspx [accessed 8 April 2013]. The paper (Bhandari, 2002) summarises key lunar science research and outstanding questions such as the origins of the Moon and the presence of water. Bhandari published again in 2004 when the mission was named as Chandrayaan-1 a paper titled *Scientific challenges of CHANDRAYAAN-1: The Indian lunar polar orbiter mission*, which was introduced, "The purpose of this article is to involve the scientific community of the country in formulating the best possible objectives and participating in the mission" (Bhandari, 2004, p. 1489). In 2005 Bhandari published a further paper which gives a much more detailed overview of the mission and its payloads. This paper stated, "The main objective of the mission is simultaneous chemical, mineral and topographic mapping with the specific goal of understanding the early evolution of the Moon." (Bhandari, 2005, p. 702). This paper provided a diagrammatic image of the spacecraft. A special issue of the *Journal of Earth System Science* December 2005 Vol. 114, No. 6 was dedicated to the Moon mission including papers from China, US and Japan. The objectives can also be traced to the scientific and technical issues discussed in these papers.

No mention is made here of the purpose of mineral mapping. There is no cultural or political inflection in these objectives, although mapping and the acquisition of high-end technology are both irrefutably entwined with political histories and political aims. The only sense that an agenda could be read into these anodyne objectives is the emphasis put on the data of Chandrayaan being "for scientific utilisation by scientists". The double emphasis on science gives away an alignment that goes deep into questions of the relation of science to Indian society and identity (Prakash, 1999; Raina and Habib, 2004; Chadha, 2005; Kumar, 2006; Raj, 2007; Sarukkai, 2012). Chandrayaan – as will be made more clear through this chapter – breaks from the societal model of spacefaring adopted by the Indian space programme, and rather than serving society in general is aligned with scientists and the pursuit if science. This shift in accountability of ISRO's satellites from benefitting the less privileged sections of Indian society to benefitting the more evidently privileged scientists[93] appears to be a shift that requires careful public relations management, as will be made clear later. Briefly, Chandrayaan presents a contradiction because the emphasis on science rather than society at once points to a moment in the nation's history at which development needs no longer require attention – the pursuit of space science is a mark of India's equal place in a comity of developed nations – but at the same, the evidential presence of poverty in the country make it clear that Chandrayaan signals a disavowal of the majority of it people. There is a veiled contradiction here though because somewhat lost in this sense of disavowal, which becomes over-compensated for in public commentaries, is the fact that the Indian constitution states the duty of every Indian citizen is to inculcate the scientific temper. If this is so then the scientific emphasis of Chandrayaan should be understood as for all citizens who, dutifully, share scientific ways of thinking: A scientific mission *is* a societal mission in the logic of the state.

The terms of the sharing of the Moon mission in a wider social domain are hinted at in a publication aimed at children, students and general readers and produced at the ISRO Headquarters in Bengaluru, called *Chandrayaan-1 India's first mission to the Moon*, (Datta and Chakravarty, 2008). Here the scientific and mission objectives are expanded upon in terms that

[93] There is a tendency also for science institutions to be predominantly Brahmin.

allude to the political-social-educational impact of the mission, both nationally and internationally. Firstly, the mission is stated to be a suitable response to "renewed international interest" in the Moon, in reference to the other Moon missions by the Chinese, Japanese, European and United States space agencies.[94] Secondly, the mission is stated to be a way to encourage youngsters to work on future space projects and in general to work in science. Thirdly, the mission is stated to have the support of university academics, who are identified as a significant user group for the spacecraft data (Datta and Chakravarty, 2008, pp. 19-20). The book has at least two versions and in the earlier version, mention is also made of Chandrayaan auguring an imaginative new phase for the space programme (Datta and Chakravarty, 2004, p. 5) though the precise nature of this new phase is not given. This publication makes a gesture towards the ripple effect of the mission onto a wider social realm.

In the handful of publications that have been written about the mission and published in India, all make some gesture towards a cultural realm that serves to reinforce the legitamacy of India's quest. These include mythologies of Soma the Moon god who is transported across the skies by a chariot of horses and the god Ganesha's quarrel with the Moon because of which he curses the Moon so that it fades away each month. References to religious festivals that are held according to the Moon's phases and associated rituals in Hindu, Muslim and other faiths are included in some as well as reference to famous film sequences and songs such as 'Chanda mama door ke'. In some the link to ancient science is made alongside the mythological with reference given in particular to the mathematics of Aryabhatta, who, around 500AD, was able to measure the distance to the Moon and understood that the Earth rotated around the Sun (Rajan, 1997, pp. 3-4; Bagla and Menon, 2008, pp. 22-32; Bhandari, 2008, Preface; Datta and Chakravarty, 2008, pp. 10-11; Guruprasad, 2009, pp. 4-5; Das, 2010, pp. 1-4) In these publications the story of Chandrayaan is then seen through these histories and space technology becomes another layer in India's existing relation with the Moon.

[94] Other recent missions to the Moon include: Hiten (1990) Japan; Clementine (1994) NASA; Lunar Prospector (1998) NASA; SMART-1 (2003) ESA; Chang'e 1 (2007) China; SELENE (2007) Japan; Lunar Reconnaissance Orbiter (2009) NASA; Chang'e 2 (2010); GRAIL (2011) NASA.

Significantly ISRO does not generally have outreach teams for its missions. The ISRO Website has a link that is labeled "Public Outreach", but the button has never linked to anything (Indian Space Research Organisation, 2006). It appears more as an artifact based on the structure of education and outreach activities used by the NASA space agency. ISRO's evolution was very different from that of NASA as its public remit was embedded in its core philosophy to provide a societal programme, whereas NASA's public outreach is annexed onto the main space programmes and could be seen as compensating for the lack of address to civil needs given at its core. In ISRO's account of the sharing with publics of the new spacecraft, the fundamental embedding of the shared aims of state and citizen in the pursuit of science and spacefaring, so particular of the Indian space programme and the Indian constitution, is lost. Instead the originality of the claims of the societal space programme as well as the duty of the citizen to inculcate the scientific temper falls into a state of limbo, as ISRO appears to follow instead the expectations of the outreach models adopted by other space agencies.

Even in these summary forms of the Chandrayaan mission rationale, the central idea of it having an unambiguous mandate is called into question as the spacecraft is positioned at the convergence of complex expectations and requirements. The spacecraft is a response to the actions of other international space agencies. It is to be used by academics for research. In more esoteric ways the spacecraft guides the young people of India towards science and space industry careers. The 'science objectives' of Chandrayaan*,* which are to adopt the processes of mapping and technical systematisation as strategies for exploration, are strongly reminiscent of the colonial 'science' practices used to acquire territory by the British in India (Raj, 2007) and yet simultaneously Chandrayaan is expected to fulfill the altruistic claim to be advancing all humankind (Bagla and Menon, 2008, p. 82). The point is perhaps not to look at the possible ambiguities of these statements, but to understand why these potentially conflicting statements are believed to convey a singularity of purpose, or why the spacecraft is being explained in this way.[95]

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[95] The publications about Chandrayaan, even if not produced by the state Publications Division (part of the Ministry of Information and Broadcasting) or the National Book Trust (part of the Ministry of Human

The exploration of what kind of relation to wider publics Chandrayaan presents and the terms by which it can be shared can be further gleaned from commentaries that overstate what the spacecraft is not. That Chandrayaan is *not* a 'societal' spacecraft haunts the surrounding rhetoric of the spacecraft. The lines of its non-societal status are firmly delineated by ISRO leaders and this is supported through the public relations office in gestures that hint at an over-compensation. Official publications and director's speeches are full of justifications of the national space programme aimed at the populace. For instance in a paper delivered in 2007, not long before the launch of Chandrayaan former ISRO Chairman U.R. Rao gave a paper on *Space Technology for Revitalising the Education System* that narrated the achievements and benefits of ISRO's societal application programme leaving out any reference to Chandrayaan. Similarly the former ISRO Chairman K. Kasturirangan in a paper titled *Applications of Space Technology* (2009) makes no mention of any societal application of Chandrayaan. As if to reinforce this delineation of the roles of satellites, a publication titled *Touching Lives: The little known triumphs of the Indian space programme* came out in 2007 just prior to the launch. The book, written by a high-ranking bureaucrat in the Department of Space, S.K. Das, presents a colourful field trip around the country in which the author discovers the usefulness of space technology in the lives of rural people. He watches a lesson broadcast from satellite at a school, he talks to a farmer who has been given advice from a University-based agriculture specialist via a satellite link-up, he meets fishermen who benefit from satellite information that helps them locate fish and he finds out how telemedicine links up consultants in urban hospitals to local doctors in satellite receiving vans that visit patients in rural locations. The publication, which is given to visitors to the Department of Space, deters any critique that ISRO may be acting outside the interests of its majority populations, perhaps in favour now of not the most vulnerable in society, but in favour of the most upwardly mobile. Chandrayaan's disturbance of the space programme's foundational critique of the use of space technology as an instrument of only the

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Resource Development) carry endorsements of officials and fit into a genre publications in India of information that convey messages of the state.

elite, causes the appearance of such artifacts as the publication *Touching Lives* (2007) at the edges of the fault line it creates.[96]

Commentaries accompanying the launch of Chandrayaan invariably make reference to the societal purpose that this spacecraft does not apparently contribute to. To recall, Vikram Sarabhai had created a space programme for India that built on the idea of using the technology, developed in the course of scientific atmospheric testing, for a range of socially focused applications, such as crop assessment, meteorology, and communications. Alluding to the Space Race and the competition to reach the Moon, Sarabhai said in 1966, "If we are to rely on historical experience, man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed." And he added the much quoted remark, "We do not expect to send a man to the moon or put elephants, white, pink, or black, into orbit around the earth" (Sarabhai, 1966, 2001). His founding philosophies marked the Indian space programme indelibly as providing a different version of the link between populations of the world and spacefaring. His philosophy took the moral high ground in the face of the clearly competitive motives of the United States and the Soviet Union that were camouflaged in the rhetoric of serving all humanity. It is to this mark not only of moral high ground but also of critical reinterpretation of space technologies towards widening participation and application that the

[96] This book, *Touching Lives* was given to me on my visit to the Department of Space in August 2010. On the face of it the book gives a glowing account of the use to society of ISRO's satellites. Its dedication reads, "For the ISRO family–past and present–who have striven to conquer space and harness its potential for the common man" (2007, dedication). Despite being published by Penguin it is a 'government' book. Das writes in the aknowledgements that Penguin Books have been good to him, "and this despite the fact that it must be particularly trying to put up with someone from the government writing a book on the government". It is a government book without clearly stating the fact and yet not enirely camouflaging the link either. It is similar to a genre of books that speak in many ways for state policies and can be related to the history of state publication in India and the socialist roots of the Republic. Former President and ISRO scientist A.P.J. Abdul Kalam's books on space technology and the future of India such as *Envisioning an Empowered Nation: Technology for Societal Transformation* (2004) could be included in this genre, also books circulated in schools such as *Bullock-carts and Satellites: The development of science and technology in India* (1985). *Touching Lives* does though have moments where glitches appear. A teacher for instance mentions feeling undermined by the television classes led by urban experts beamed into the rural school (pp. 57-9). A farmer mentions that he followed the instructions available at the satellite enable Village Resource Centre (VRC) computer, which also told him where to buy seeds, but his crops failed (p. 240). The farmer finishes by telling the author how he has benefitted from the VRC and yet there are cracks in the narratives available for the attentive reader. The farmer in this case has become dependent on information coming from outside, via the satellite and computer. This is not knowledge integrated with his own knowledge and there are clear problems also that the farmer alludes to with the esoteric language of chemical fertiliser products recommended to him. It is possible to read through the glowing report and speculate whether the author has allowed these problems a certain transparency in the book in ways that evade censorship.

new rhetoric of the Moon mission has to contend and somehow make peace. On the day of the Chandrayaan launch itself on 22 October 2008, Rakesh Sharma, the Indian astronaut who had flown in a Soviet Soyuz craft in 1982, commented on the turn to the Moon in this way, which includes a reference to Sarabhai, acknowledgement of the formational vision of the Indian space programme and a justification for Chandrayaan as a new phase in the space programme:

> Certainly it announces to the world that ISRO has kind of 'come of age' and is now ready to take on science and exploration in a big way, having already translated the wishes of Sarabhai, to have science work for the common man, so after a successful applications programme, here ISRO is really investing in the future and I see no reason why they are not going to achieve the same level of success as they achieved in the first phase of their programme. (Bharathnbk86, 2008).

His statement reflects on the associated concern for the societal, or as it is also called the "applications programme" while welcoming Chandrayaan as auguring a new phase. His comments provide a scripting smoothing over the cracks in this expensive technology's relevance to the citizens that have funded it. The mission is presented as simply extending an existing trajectory.

Other kinds of shifts in the motivations embedded in India's space technology are evident in a presentation given in 2010 titled 'The Story of Chandrayaan', made by ISRO Director Shivakumar, in which he reflected on the launch. In this presentation, Shivakumar summarised for an audience, in a relatively informal and unscripted public presentation, the rationale for the mission as it appeared to him in the following stages. First, that ISRO had achieved competence in Earth satellite technology:

> ISRO embarked on space science mission only when we were convinced that we have been able to reach a stage when we can think of something other than what we do around Earth. With the remote sensing programme and the communications programme reaching a maturity, so saying that we know how to make satellites in India. (Shivakumar, 2010)

In the intervening years between Sarabhai's visionary and innovative declaration to apply space technologies to grassroots problems, India had developed numerous remote sensing satellites (the IRS series) and satellites for direct broadcast television (the INSAT series). ISRO is particularly known for its Earth imaging capability, a branch of its work that began when

Rakesh Sharma took photographs from space that formed the base data set. Chandrayaan was essentially another imaging satellite, except imaging the Moon and not the Earth. Shivakumar went on to describe two other technological components ISRO already had that meant it could easily send a spacecraft to the Moon – a rocket and a tracking system with which to communicate with the satellite, saying, "We also have said how we can make launch vehicles to carry satellites to required orbit, we also demonstrated that we know how to control these satellites in Earth orbit". Just as Sharma's commentary, he then demonstrates the lack of conflict with the societal programme:

> We proved to the world, and to ourselves in the country, that we know how to use this satellite for the benefit of the common man in the society. That is what we call the 'grassroot level'. Impact was felt by all Indians. We found that we have nothing to do but to look forward. (Shivakumar, 2010)

Shivakumar here acknowledges the success of the societal phases of the programme saying, "Impact was felt by all Indians". His version of the story emphasises the technological steps to space that ISRO took by first building a rocket that could take a payload to orbit, then building a satellite and the infrastructure to operate spacecraft in deep space. He indicates here that the Moon mission is only a slight adaptation of remote sensing satellites, which India has been producing for decades. Chandrayaan is a remote sensing satellite surveying the Moon instead of the Earth. Of the turn to the Moon and the incorporation of this mission into the portfolio of the space agency, he continued:

> Having done this, let us continue to do so. That becomes a lifeline for the country, income from satellites, satellite applications, and how to manage satellites and everything. But at the same time one really has to worry about the quest for human knowledge. So when we looked at that we said that ok Moon is nearest body that we can think of, and why don't we go to Moon. (Shivakumar, 2010)

The remote sensing and communications satellites of ISRO had already shifted the societal model of space technology to a more neo-liberal programme, which grew into a successful commercial business model, providing what Shivakumar calls here, "a lifeline for the country" in terms of its income generation.[97] As a result of this success the Antrix Corporation was set up as the commercial wing of ISRO (see Figure 11), as part the government Department of Space and also under the auspices of the Space Commission and Prime Minister for handling the income generation from remote sensing imaging. As Director of ISRO's tracking facility and later the satellite assembly unit, Shivakumar's perspective and explanation is that of a technologist and pragmatist responsible for an organisation. He appears to glance over the rationale of the Moon mission stating that spaceflight fulfills a need of humankind, "the quest for human knowledge", but like many technologists who appear bounded to material fact, his rendition of the mission's objectives ends with an almost mystical question of what humanity's quest in spaceflight really is.

ii. Images and models

The explanations of Chandrayaan's mission given above involve reductions, remixes and transference that can be discerned more readily through images and objects. In visual representations of many kinds, the entity of the spacecraft becomes separated more noticeably from the originating circumstances of the workplace and transformed into a singular, visibly autonomous, technological object. As an image, Chandrayaan often appears diagrammatically as the kind of technical rendering produced by engineers using computer aided design software. One of the first images of Chandrayaan of this kind was published in a paper by the lunar scientist Narendra Bhandari titled 'Chandrayaan-1: Science goals' (2005) and is reproduced in Panel 5 (Figure 13). This image of Chandrayaan was used in the paper to indicate the positions of the payload instruments. The spacecraft in this image is box-shaped with a circular crown and to the left is an indication of a solar panel. Instruments are distributed on the circular crown, on the side of the spacecraft body and inside what looks to be an alcove. A green panel that appears as if it would close the alcove is covered in orange dots and labeled "MINI-SAR"

[97] Neoliberalism refers here to a key shift in Indian economic policy when India became open to foreign investment in the 1990's. This had implications for the space industry. (Finance minister Manmohan Singh negotiated a loan from the International Monetary Fund and as part of this deal India's trade borders were opened)

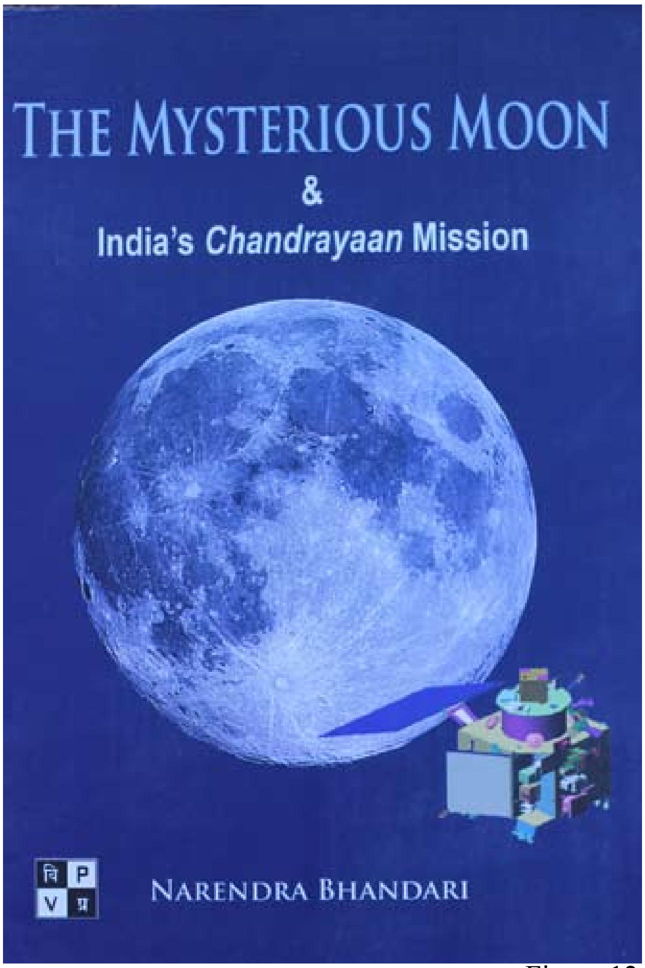

Figure 12

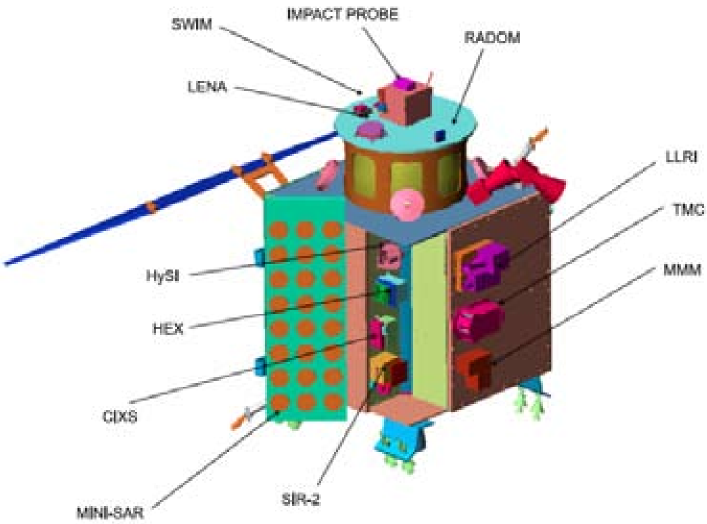

Figure 13

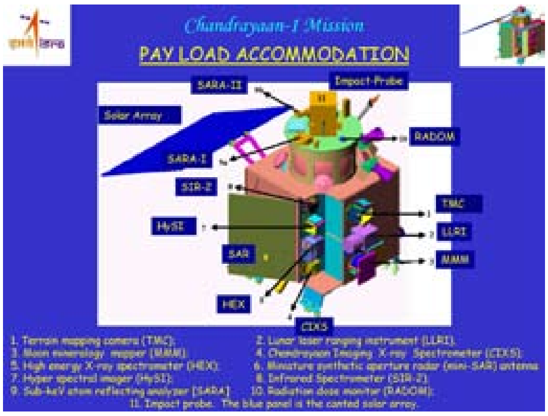

Figure 14

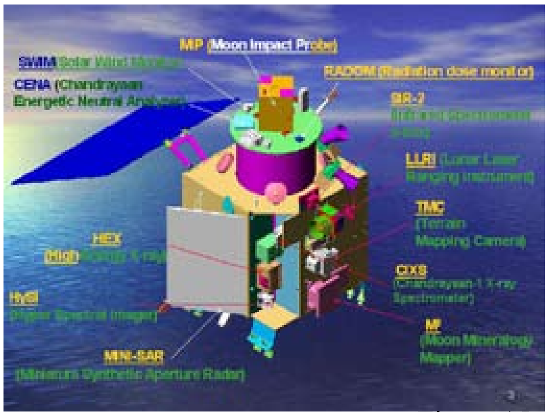

Figure 15

Figure 12 shows the cover of a book by Narendra Bhandari about the Chandrayaan Moon mission punblished in 2008. The image of Chandrayaan used here is similar to the technical renderings of the spacecraft and its instruments used in scientific publications and presentations. **Figure 13** shows one of the first images of Chandrayaan released into the public domain in the *Journal of Earth System Science* published by the Indian Academy of Sciences, in a paper by lunar scientist Narendra Bhandari titled 'Chandrayaan-1: Science goals' (2005). **Figure 14** is a slide from a presentation given in 2007 by Ben Bussey a NASA scientist working on the Mini-SAR instrument onboard Chandrayaan. **Figure 15** is an image found online (Chandrayaan-1, 2012, http://weebau.com/satplan/chandrayaan%201.htm). *(Figure 12 reproduced courtesy of publishers Vigyan Prasar; Images of Chandrayaan reproduced courtesy of ISRO)*

(Miniature Imaging Radar Instrument). The spacecraft is presented in this image as if standing on tiny feet or supports, which are small propellant motors. In another image (Panel 5, Figure 14) used a couple of years later, this same picture appears together with a similarly diagrammatic rendering of the spacecraft on a PowerPoint slide used by one of the NASA scientists working on the Mini-SAR instrument (Bussey, 2007). The image used in the paper by Bhandari (2005) appears in the right corner of each slide. In the slide shown is a slightly different diagram of Chandrayaan. It again illustrates the positions of the payload instruments but now they have now slightly changed names and positions. The spacecraft is shown still with a circular crown, but now with a slightly clearer solar panel. It has a similar distribution of instruments, but a larger green Mini-SAR panel without the orange dots. This schematic image of Chandrayaan can be found in images online in other variations, such as one in which it is set against sky and ocean (Panel 5, Figure 15). There are slight changes again in the diagram's colouring with the green panel now grey and the top crown a bright pink.

This rendition of Chandrayaan becomes a fairly widely used image. It appears for instance as part of a book cover illustration (Panel 5, Figure 12). This book, *The Mysterious Moon* (2008) is by the same author, Narendra Bhandari, who led the development of the scientific rationale of Chandrayaan and in whose article 'Chandrayaan-1: Science goals', the first image discussed (Panel 5, Figure 13) was presented. Here on the book cover, the image is used illustratively to depict the idea of the spacecraft orbiting the Moon. The book cover presents two different representational schemes: A photographic-style depiction is made of the Moon, while the spacecraft is depicted as a schematic engineering model. Versions of these technical renderings of the spacecraft appear elsewhere in museum exhibits, leaflets, stickers and other publications (Panel 6, Figures 16-19). It can be argued from these examples that the passage to the public realm from the technical and scientific community is not severe. The spacecraft is not illustrated as if in space but holds to the authenticity of its origins as a technical rendering. The spacecraft in the public realm is depicted very much as it is in the space agency realm.

As well as an image, Chandrayaan is also presented as a model. Two versions used by the ISRO public relations unit are shown on Panel 7. The first photograph (Panel 7, Figure 20) was taken

Panel 6

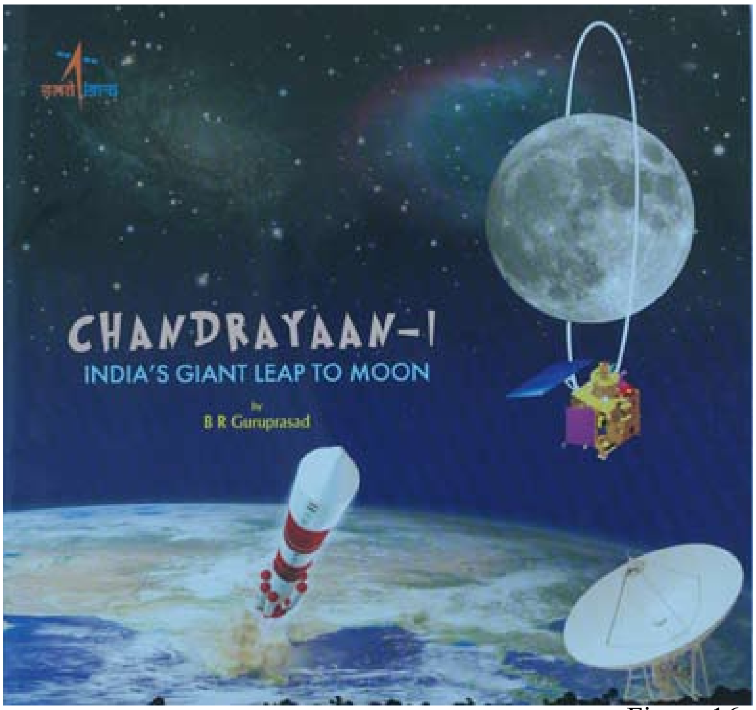

Figure 16

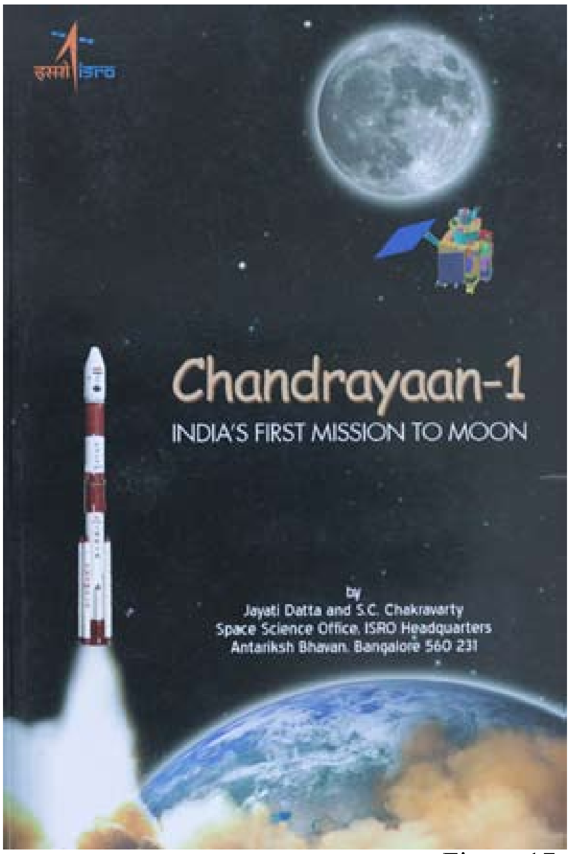

Figure 17

Figure 18

Figure 19

Figures 16-19 show instances of a similar image of Chandrayaan appearing in public media. **Figure16** is the cover of a book about Chandrayaan for children written by ISRO Public Relations officer B. R. Guruprasad (2009). **Figure 17** is the cover of a book about Chandrayaan produced by ISRO for general audiences (Datta and Chakravarty, 2004). **Figure 18** is a sticker for the Chandrayaan mission given out by ISRO Public Relations office. **Figure 19** shows a panel explaining Chandrayaan's journey to the Moon displayed at the Jawaharlal Nehru Planetarium, Bengaluru in September 2011. (photos: the author) (*Images reproduced courtesy of ISRO*)

Figure 20

Figure 21

Figure 22

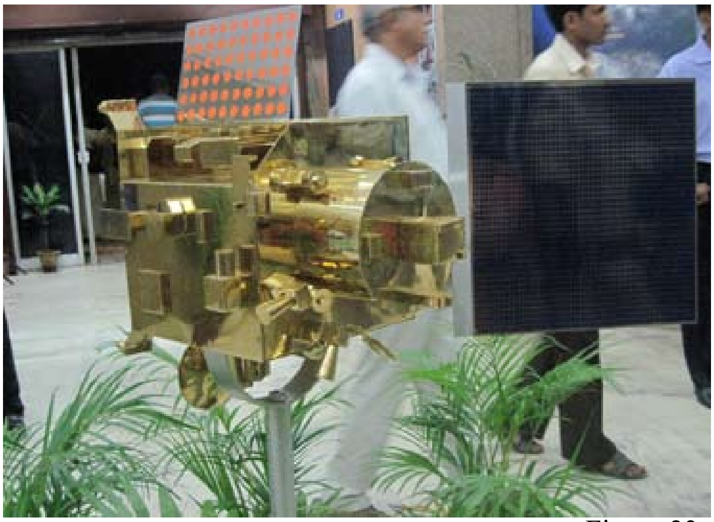

Figure 23

Figures 20-21 show two exhibition models of the spacecraft Chandrayaan. **Figure 20** shows a model exhibited at the Bengaluru Space Expo 2010 trade show held just outside Bengaluru. **Figures 21-23** show views of a smaller model of Chandrayaan photographed at the Jawaharlal Nehru Planetarium in Bengaluru (27 August 2011) at the inauguration of a new planetarium show entitled *The Scientific Moon*. (photos: the author) at the trade show in Bengaluru called the Bengaluru Space Expo 2010. The model stands at about 7 foot high, slightly higher than a person. In this photograph it is displayed next to two circular images one of the Earth surface and one of the Moon surface. Both are satellite images taken from remote sensing cameras on spacecraft and indicative of ISRO's new capability to survey not only the Earth but other planets. Unlike the colourful schematic images discussed previously, the spacecraft model is covered in gold to represent the thermal heat shield blankets that cover the spacecraft. The model has a large solar panel to one side and a small antenna in front, which did not appear in the diagrams. The orientation of the spacecraft though is still like that of the schematic diagrams with the circular crown at the top.

The upright posture of the spacecraft is even more accentuated by its stand that gives the model roughly human proportions with the stand suggestive of legs. The other photographs on Panel 7 (Figures 21-23) are of another much smaller model of Chandrayaan. The orientation of the spacecraft has changed. The rocket thruster is now to the side (Figure 22) rather than underneath as in the larger model. Instead of 'standing' the spacecraft is now 'in flight' and travelling with the circular crown forwards. The MINI-SAR panel is depicted with distinct rows of orange dots similar to Figure 13. The antenna is elegantly rendered on this model underneath the spacecraft body (Figure 22). The gold-coloured brass with which the model is made gives it a trophy-like appearance. Palm plants surrounding the model give some protection although the use of plants is also indicative of an official occasion. The occasion in this case was the inauguration of a new presentation at the Jawaharlal Nehru Planetarium in Bengaluru called 'The Scientific Moon' (2010) based on Chandrayaan's mission and opened by the new Governor of Karnataka and the former ISRO Chairman and Chairman of the Governing Council of the Planetarium U.R. Rao.

These two models belong to a lineage that go back to the first model of Chandrayaan which was presented at a international conference in Udaipur in November 2004. Images from the press conference publicising the Moon mission show a small spacecraft model being held up by the ISRO Chairman Madhavan Nair and the Chandrayaan mission Director Annandurai, for publicity shots. In front of the elated directors are microphones and press photographers, behind is a huge photo of a rocket launch. The press images from that day therefore show key figures from ISRO surrounded by plumes of smoke and holding the diminutive replica spacecraft. A model of Chandrayaan, perhaps the same one depicted in the press photographs, was also taken to the Tirupati temple before the launch for *puja* blessing.[98]

These models of Chandrayaan also belong to a prolific genealogy. Spacecraft models have peppered the conference halls, trade shows and offices of space agencies through the history of spaceflight. In general they make only occasional appearances in more public spaces. The two models shown in Panel 7 for instance are used almost exclusively by the ISRO public relations unit for trade show exhibits that are aimed at the space industry. The first was taken at a trade show which though open to the public was some way outside Bengaluru at a conference centre that required personal transport to reach. The second photograph was taken at an inauguration event open by invitation only. These models form part of the public-facing representation of Chandrayaan, although they are actually used mostly within the industry and rarely leave the space agency communities. They convey the achievement of the space agency back to itself and to the rest of the space industry to which they are almost exclusively presented. As such their purpose is much more as internal trophies, presenting perhaps what it is that the space agency thinks it is providing for a public realm but in reality is much more contained within the communities of the space industry.

The representations that exist of Chandrayaan have a haphazard emergence. The curators of the Space Gallery for instance in Bengaluru's Vishvesvaraya Industrial and Technological Museum

[98] 'Puja' is a Hindu blessing ceremony. Such *puja* blessing of technological objects suggests a layer of spirituality that presents an interesting conundrum because it appears to go against the professed rationality of science. As Sundar Sarukkai has proposed in his paper 'Praying to Machines' (2003), the fullness of technological imaginations in India do need to allow for accompanying and protecting gods. However, *puja* ceremonies enacted in institutions such as ISRO also reinforce a Brahminical hierarchy (Brahmins are the highest caste in India and also the priest caste). This can have the effect of marginalising non-Brahmins as well as non-Hindus within the science profession. Sarukkai suggests that offering prayers to machines may evoke unease with technology in India, a need to bring technology inside 'Indianess' through a practice that feels more indigenous. Raminder Kaur's study of theatrical tableaux displays made for the festival of the Hindu god Ganesh (called Ganpati festival) in Mumbai reveals rich visual collaging of prestige technologies, gods and politicians that evidence an interchangeability between powerful public icons that include state technology, gods and Bollywood celebrities (Kaur, 2003). That such practices become part of a state-run, science and technology institution questions both the extent to which the state is secular and the extent to which scientific prctice is entirely rational. These practices are not marginal either but institutional rituals. One day when I visited the Indian Institute of Astronomy a ceremony was being led there by the institute Director. In ISRO's tracking station photographs of the inaugaral *puja* ceremony are on display inside the antenna building where the ceremony took place, led by ISRO Chairman Madhavan Nair.

intended to have a model of the spacecraft in their exhibit, but in the event none was made. Instead the museum has an area of descriptive boards, video and an interactive table-top projection of the Moon indicating landing sites of spacecraft. By including such a gap between intention and production it is possible to consider the production of the imagery of Chandrayaan having a haphazard emergence, dependent more on availability of imagery and resources than on the deliberate production of a specific type of representation. The schematic images in Panel 5 borrowed from the design engineer and incorporated into scientific papers, an internal PowerPoint presentation and then appearing on a book cover are not illusory images. They indicate a certain investment perhaps in the technical over the 'artistic' rendering. Or perhaps the colours of pink, verdigris and blues – from a foreign perspective so quintessentially Indian – were simply appealing enough to be used repeatedly. Or perhaps this representation serendipitously came to be established as recogniseable and therefore iconic. The journey of the schematic image to the public domain shows little evidence of having been manipulated for the taste of a public audience separate from the scientist-makers; it feels like it had barely left the engineer's drawing room. Yet some of the imagery and replicas of Chandrayaan become fanciful as they stand to attention (Panel 7, Figure 20) or loop around the Moon (Panel 6) becoming a caricature of the spacecraft and very different from the instrument carrying bus designed by the scientist-makers.

On the whole, the images and the models present the spacecraft for a societal realm defined by its redundancy within the mission yet familiar with the respect given to science and engineering. The representations nonetheless provide a reduced, simplified version of the mission designed for those outside the site of production with little opportunity to build an image or understanding of the mission directly from the authentic site of the spacecraft's production. Some of the representations present a conundrum because they are rarely seen in public spaces and exist more as catalogue devices indicating expediently to the rest of the space industry ISRO's space products. In so doing, these images and models tend to reinforce a reading of the spacecraft as a singular entity, an object, rather than distributed through an infrastructure of materials and human cognition, as was the more evident characteristic of the spacecraft viewed from the production workplace.

The rocket and the spacecraft

The iterative emergence of an imagery of Chandrayaan*,* in which details change and altogether conflicting versions can appear side by side, is also symptomatic of the confusions of its origin. In Panel 6 the depictions of Chandrayaan shown are accompanied by a red and white striped rocket called the Polar Satellite Launch Vehicle and invariably referred to as the PSLV. In these images Chandrayaan and the PSLV rocket have a symmetrical relation. This relation veils a less evident aspect and origination of the mission, which is Chandrayaan's dependency on the rocket, its by-product even. For the PSLV as an icon of State and national achievement has a pedigree that in many ways outshines that of the spacecraft. The rocket if reinstated into this narrative of commentaries and representations of Chandrayaan, draws out of the shadow a purpose of the launch somewhat lost or displaced. Chandrayaan was in some ways a demonstration vehicle for the PSLV's capabilities. An awareness of this more subliminal and unstated reason for the Moon mission indicates other dimensions to the Moon mission tied to the iconic status of the PSLV rocket and the Moon and the imaginary of an new style of nationalism emergent in the late 1990's in India. Imagery in the Space Gallery at Bengaluru's Industrial and Technological museum shown in Panel 8 reinforces the triad of the idea of the Moon, the rocket and the Indian nation. Such imagery and imaginary crystallised into the exhibition design of the Space Gallery inaugurated in 1999 is emblematic of the emerging politics of aggressive nationalism prevalent at the time the Moon mission was first proposed. The conjuncture of this triad is self-evident in the wall size photographs (see Panel 8) displayed in the Space Gallery, which was opened in 1999, the same year that the Moon mission was announced by Kasturirangan on Technology Day.

The combined technological and nationalistic imaginaries constructed into the public spaces of space technology, add to an array of unscientific uses of the spacecraft. Lunar science in this

Panel 8

Figure 24

Figure 25

Figures 24 and **25** show wall size posters of a PSLV rocket launch, a satellite image of the Indian subcontinent and a image of ‘Earthrise’ from the Moon. The photographs were taken in the Space Gallery at the Visvesvaraya Industrial and Technological Museum in Bengaluru in July 2012. (photos: the author) context becomes a vehicle for the demonstration of rocketry and rocketry is a potent icon for *swadeshi* or national self-reliance, a concept bonded to Indian technological pursuits.

A shift in the imaginary of space programmes led to the shifts in policy that allowed for the political, technical and imaginative consideration of the Chandrayaan spacecraft to develop. This turn can be traced to origins preceding the spacecraft. They relate to a context not of launch in 2008 but of the mission inception around 1999 prior to which there was a gradual remoulding and disassociation from the grassroots, everyday, societal space programme. This remoulding is associated with rocket launches and the comparable explosive event of nuclear tests carried out in India in 1998. The realignment of the meanings of space technology indicates how the technology, its imagery and its associations can be purloined strategically.

One such case are the associations brought to space technologies by the commentaries of A.P.J. Abdul Kalam who was President of India from 2002-2007 during the time period of Chandrayaan's government approval and construction. Kalam is a national figure of comparable standing to Sarabhai. He is thought of as a visionary political leader but notably he is also a former space technologist. In 1999, before he became President, he published his memoirs *Wings of Fire* that focus mainly on his experience developing India's first Satellite Launch Vehicle, popularly known as the 'SLV'. He worked under Sarabhai and also the subsequent ISRO Chairman, Satish Dhawan. On 18 July 1980 the SLV was successfully launched after an eventful period of development and Kalam writes of the resounding significance of this event, “Parliament greeted the achievement with the thumping of desks. It was both the culmination of a national dream, and the beginning of a very important phase in our nation’s history”. Kalam then adds this anecdote that ISRO Chairman Satish Dhawan, “threw his customary guardedness to the winds and announced that it was now well within our ability to explore space.” (Kalam, 1999, p.100). The inclusion of this anecdote is important because it sets the framework of a vision for space exploration that no longer dispels the ambition for the Moon.[99] What matters here is not whether Satish Dhawan said this or not, but that Kalam includes this in a narrative,

[99] As a reminder Sarabhai had suspected the motives of the Moon missions of the late 1960's and early 70's saying that India had no such ambitions but would instead establish the needs of its people as its priority (Sarabhai, 1966, 2001).

published in 1999, the same year as Kasturirangan's Technology Day announcement of Chandrayaan, which introduces a different scripting of the story of the space programme.

Kalam's intervention into the imaginary of the space programme as experienced in the public realm goes much further than this anecdote. His publications (1998; 1999; 2002; 2004; 2010) are only a partial document of the influence he has had through his public life, but they summarise a position for technology within a particular national imaginary and social imaginary. His reflections constitute another re-scripting in which the compassionate, societal correspondence of satellites with everyday life is usurped by a new vision in which national technological capability is linked to national transformation through personal transformation. Another book by Kalam *Ignited Minds* (2002), written primarily for young people, illustrates this shift in the level and type of bond between the social and technological being constructed. In this book Kalam normalises the entanglement of civilian and military applications of technology by recounting his own biography in which he worked on the civilian SLV and then the Agni missile while taking time to work on the (philanthropic) spin-off development of prosthetic limbs. These experiences with technology are superimposed onto his own 'transformational' life story in which he rose from humble beginnings in the small town of Rameshwarem, through the ranks of ISRO to become President of India. Kalam concatenates ambition, transformation and aspirational dreams with military and space technology, nationalism and childhood. It is a move through which the societal link with space technology shifts from an everyday, workplace level of engagement, to a more psychological level, in which the height of rockets equates to the formation of personal identities via the 'ignited minds' of young people.[100]

This fire of launch rockets is of significance and it correlates with another fiery explosion of comparable scale – the detonation of India's nuclear bomb on 11 May 1998. That date was

[100] The ghostwritten publications of A.P.J. Abdul Kalam comprise books on the scientific and technological vision for India written for general audiences, but they are versions of the national policies that he influenced. The titles give a good sense of a body of works that is influential in constructing a particular role for large-scale technologies in public life: *India 2020: A Vision for the New Millennium* (1998); *Ignited Minds: Unleashing the Power within India* (2002); *Envisioning an Empowered Nation: Technology for Societal Transformation* (2004); *The Scientific Indian: A Twenty-First Century Guide to the World around Us* (2010); and biography for children by Srinivas Laxman, *Dreams to Reality: A Biography of Dr A.P.J. Abdul Kalam* (2004).

named Technology Day in honour of the achievement of the nation, an achievement that had wide popular support. The contradictions within the politics of the bomb have been analysed by the international relations scholar Itty Abraham (Abraham, 1998; Abraham et al, 2009) and also the writer Amitav Gosh (1999) while cultural studies theorist Raminder Kaur has studied the weaving of politics together with the ubiquitous image of the nuclear bomb into vernacular presentations during the Ganpati festival in Mumbai (Abraham et al, 2009; Kaur, 2003; 2013). A year after the underground explosions at Pokharan, as part of a day of celebration over the detonation of the bomb, Kasturirangan announced on Technology Day 1999 India's capability to send a spacecraft to the Moon. As Itty Abraham, Amitav Gosh and Raminder Kaur show in their analyses the detonation was strongly linked to the right wing, pro-Hindu (Hindutva) political leanings of the ruling Bharatiya Janata Party (BJP). As Amitav Gosh suggests (1999, pp. 5-6) in his short book *Countdown* (1999) the political rewards of the nuclear blasts as a show of impressive technological capability turned out to be short lived. The possibility then, coming a year after the nuclear tests, of a spacecraft launch incorporating not only fire, but also an association with the Moon, can be readily positioned within the same political agendas as that of the nuclear tests.

Two points will be highlighted here. One is that, from this perspective the launch announcement has a strong relation with the circumstances that led to the detonation of the atomic bomb. Abraham's insight that the atomic blasts were the result of a "mistake" in which the idea of explosions appeared to provide a solution for the political insecurities of the BJP party has relevance to the decision to launch to the Moon. The second point to note is that what was envisaged in 1999 was not an awkwardly shaped gold covered box called Chandrayaan. The spacecraft had no name and no form at that time. What was envisaged was a spectacular and internationally publicised launch of a red and white PSLV rocket. The PSLV rocket was a national icon in 1999. Its image accompanies virtually all depictions of the more delicate, oddly-shaped spacecraft.

To help locate this perspective and its imaginaries, the Space Gallery in Bengaluru's Visvesvaraya Industrial and Technological Museum, which opened in 1999, provides evidence of what was deemed important about space technology at that time. The background to the Space Gallery's inauguration is that in the late nineties, after canvassing public opinion it became clear to the curators of the Museum that there was a high level of interest in India's spacefaring achievements. In particular there was widespread interest in the success of the Satellite Launch Vehicle, the so-called SLV, launch in 1994 (which Abdul Kalam had worked on), and the even more powerful Polar Satellite Launch Vehicle. By 1999 the red and white striped PSLV had become a prominent symbol of India's self-reliance.[101] A film reel that loops in the Space Gallery, made in 1998 bears witness to the mood and significance of space technologies at that time. It is constructed with some footage from another film about the space programme made in 1971 by Vijay B. Chandra called *Space and India*. This earlier film showed how the space programme at that time consisted of balloon and sounding rocket launches to collect atmospheric data, together with proposals for remote sensing as well as data and television communication satellites. Rocket making is shown in the 1971 film to be part of the everyday activities that happen in India alongside other activities such as farming and child rearing. The 1998 film has a similar collaged syntax and types of shots, but the message has shifted. Now the title of the film reads, not as the associative *Space and India*, but the assertive *India in Space*. The reel is made of two films. The second has the similarly forthright title *Harnessing Space - In the Service of the Nation.* Over imagery of the launch pad at Sriharikota, and of women and men working on the fabrication of the rocket in clean-room workshops, the voice over commentary notes, "Today India is a nation on the move, a nation in a hurry to claim its rightful place among the comity of nations of the world" (*Harnessing Space*, 1998). Then begins a slow rising pan showing the PSLV ready for launch which is described in this way:

> The prestigious rocket of the Indian Space Research Organisation ISRO symbolizes the hopes and aspirations of the modern, resurgent India. As tall as a 15-story building, the PSLV weighs an awesome 300 tons of which more than 80% is propellant alone. The lifting power of the PSLV can be gauged from the fact that the first stage alone burns over 190 tons of solid propellant in less than 2 minutes. (*Harnessing Space*, 1998)

[101] Self-reliance, or in Hindi, *swadesh*, is a potent term in Indian. The idea of swadesh is associated with the values promoted by Gandhi who for instance wore cloth that he himself had woven. Gandhi argued that self-reliance would lead to *swaraj*, or self-rule (see *Hind Swaraj* written by Gandhi in 1909 and *The Story of my Experiments with Truth* published in 1940).

In this film the red and white PSLV rocket is portrayed as the product of its workforce: It clearly provides jobs for men and women of a scientific and technical nature. But it is also an icon of the nation, it "symbolizes the hopes and aspirations of the modern, resurgent India". The workforces of the rocket are the exemplary products of its modernising influence. The films *India in Space* and *Harnessing Space* displayed in the Space Gallery from 1999 and still running, point to the significance of the red and white striped PSLV rocket in forging the Moon mission. Significantly, in this light, Chandrayaan is a prop designed to demonstrate the strength of the rocket. To recall Kasturirangan's announcement on Technology Day 1999, "that the PSLV could undertake a mission to the moon" (Bagla and Menon, 2008, p. 82), what he actually referred to then was the capability of the rocket. The imagery and imaginary of the rocket is close to the imagery and imaginary of the atomic bomb.

Abraham's appraisal of the way the nuclear tests were used by the state to produce an image of power correlates almost seamlessly with the presentation, in public-facing media, of the PSLV rocket, confirming the resonant power of visual imaginary. The central issue Abraham pursues in his analysis is how and why the Indian State needed a demonstration of nuclear capability: an explosion. He questions the function of the nuclear tests in relation to India's changing politics. To briefly explain his argument, India had always refused to sign the Nuclear Non-Proliferation Treaty (1970), "not because it wanted to develop its own weapons but because the treaty was discriminatory, creating two tiers of states in the international system". The nations with nuclear weapons were at this time telling nations without nuclear weapons that they could not develop their own, but none of the nuclear nations were offering to give up or disable their own capabilities, so the treaty looked hypocritical and India would not sign up to it. However, some years later during another round of negotiations focuses on the Comprehensive Nuclear-Test-Ban Treaty (1996), this stance had become out of kilter with other second tier nations (nations that did not possess nuclear weapons) that were now less concerned with the hypocrisy of the treaty and more concerned with the need to 'non-proliferate'. Now, India's refusal to sign, "looked like nothing more than the actions of a country that wanted to have nuclear weapons and that would not sign a treaty that might obstruct that goal" (Abraham, 1999, p. 3). India had changed its stance completely from the years of Nehru's governance characterised by moral leadership (Guha, 2007, Chapter 8). However, the detonation of the bomb presented an anomaly in other ways too. The testing of the bomb did not mean that the infrastructure was in place with which to use a weapon against another country so Abraham interprets the tests instead as symbolic instruments of state power giving visual evidence of strength through a show of technological capability. State power is tied to the visuality of large-scale technology. The concept of the fetish helps to clarify that a displacement occurs in the process of constructing the meaning of a bomb that did not constitute an actual defence system and was out of kilter with world opinion. In this process, the original intentions of the makers, the scientists, was also wrested from them, as employees of the Department of Atomic Energy had no rights to publically discuss their work. So in the absence of their commentary, a different imaginary of a political nature could be superimposed onto the explosions. A strong correlation between nuclear technology and space technology can be made around the image – seen or imagined – of a fiery explosion, which both bombs and rockets produce in abundance.[102]

The actual imagery produced of Chandrayaan departs though from this visual imaginary. Fires are not well suited to oxygen-free outer space. In its depictions the spacecraft orbits calmly, its shape lacking the visible power of the rocket. The many locii of its origins however produce an anxious and turbulent space as to its purpose and its role. Certain conflicts emerging from lost origins, from immaterial processes of meaning making and meaning-displacement manifest in the confusing remixes of rationales and imagery that pervade the affective space of the spacecraft as it makes appearances in the public domain. The points of departure from which ideas are articulated by persons and then disseminate in almost untraceable ways widely or narrowly across public spheres are sites at which meanings converge and can be constructed.[103]

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[102] See Raminder Kaur *Atomic Mumbai* (2013a) for discussion on the visuality of nuclear technology, which like space technology includes the potent visuality of what is not directly seen: the explosions were underground and resticted, actual weapons are, like space technologies only known to wider publics through image reproductions.

[103] This discussion of ties between the changing political climate in India, evolving technology and the production of imagery can be broadly understood in terms of a *shifting imaginary* of space technology. Towards the end of this chapter this interplay has here been discussed with reference to events around 1999 when the idea of a Moon mission began to enter the public realm. In 1998, on the day that India began the nuclear tests President Clinton announced sanctions against India because the tests violated the

Summary

Marx's concept of commodity fetishism introduced at the beginning of the chapter refers to the act of buying a commodity and forgetting, or obviating, the processes and conditions of its production. In a sense, the authorship present in the making is replaced with the thrill of ownership. There is within Marx's theory of capital a pattern of 'disappearing' as money becomes a substitute for products and as ownership displaces the authorship of the producers (producers such as craft workers, factory workers or managers). In a similar way, through the public representation of the spacecraft the role of the makers presented in the previous chapter disappears to some extent. The values and significance given to the instrumentation, the collaborative, distributed emergence of the material technology and its entanglement with the lives of the large populations of the space agency workplace, become lost in translation or transference to another domain. The originating meaning of the spacecraft in its production

1994 non-proliferation act. At that time, the bravado and nationalism conveyed in imagery of the PSLV rocket can be more fully understood in the context of international trade embargoes and the consequent appearance of a feisty imagery of self-reliance in reaction to those restrictions. The closer alliances between the US and India that have emerged since 2004 had consequences for the form Chandrayaan took as a collaborative mission. In 2004 ISRO sent out an international call for payloads to join the Chandrayaan mission. The collaborative form that Chandrayaan eventually took reflects parallel shifting international relations. Relations between India and the US began to improve after 2004 and the process in some ways was led or facilitated by science and technology collaborations. The Indo-US Science and Technology Forum that began in 2000, but had been dormant for some years with no joint meetings taking place, held the India-United States Conference on Space Science, Applications and Commerce in June 2004. In November 2004 the international lunar working group ICEUM took place in Udaipur where a model of Chandrayaan was first displayed. Meetings such as this gave the opportunity for other kinds of informal meetings (alluded to in Bagla and Menon, 2008, p. 205). In 2005 work began on building what would be the Civil Nuclear Agreement that was eventually signed on 10 October 2008. This represented a hugely significant shift on the part of the US towards India after the sanctions imposed in 1998. In 2010 with the visit of President Obama to India and the cooperative relations between Obama and Prime Minister Manmohan Singh, the frictions between the two countries post-1998 were almost resolved. A chief complaint of India against the US during this time was the existence of an 'entities list' of certain companies that were not trusted because of the dual-use potential of the technologies or products they produced as weapons of mass destruction (in the eyes of the US). ISRO was among the companies on the 'entities list'. ISRO's ability to import and export was tied therefore very much to the nuclear issue which had started the sanctions. So the process of the Civil Nuclear Agreement was relevant to space technology production also, and, significantly to the imaginary space technology would be used to convey. What is not included in this chapter then is a further evaluation of Chandrayaan as a vehicle for scientific and technological collaboration mirroring, as well as reliant on, other processes of a political nature. In relation to those processes, an interview between journalist Pavla Bagla and NASA Administrator Michael Griffin is revealing of the delicacy with which space technology, language and politics are entwined (Bagla and Menon, 2008, pp.157-162).

phase is in a subtle way displaced and the identity of the spacecraft shifted, in the transference to a public-facing representation.

The disconnection from its makers, as pointed out in the previous chapter is particularly dramatic in the case of the spacecraft as this disconnection takes the form of the visually momentous spectacle of launch. As Chandrayaan loses its connection to its makers, in the few minutes of its fiery passage through the sky, its meaning, significance and ownership open to a new set of referents, constructed with less reference to the experience, authorship and intentions of its makers. Some of those referents can be related to the concept of state fetishisation. In the logic of the fetish the state takes an artifact (nuclear reactor, spacecraft) and dispels the social processes that produced it (the experiences, motivations, attachments, design decisions of the scientist-makers), replacing these with rhetoric, such as societal benefit or national strength. To draw again on the question explored in the previous chapter, "Is an individual an author of her experience?" (Sarukkai, 2012, p. 38), the logic of the fetish can be mapped onto the triad relation between experience, authorship and ownership. Without the experience of making the spacecraft and in the absence of the actual spacecraft, which is either in orbit or being constructed away from sight, fetishisation is another kind of authorship.

The argument proposed in this chapter is that through this extreme form of authorship the state determines *its* ownership of large-scale, spectacular technology and how it does this takes the form of various kinds of commentary and imagery using the many facets of public-facing representation by which to intervene into the imaginary of the spacecraft. The moves of the state to create a public-facing image of the spacecraft dissolve originating experience (the social processes that produced the technology) in order to own and possess and replace the meaning-making capability of the technology. It is the spectacle that becomes the vehicle for such authorship to take place. But the spectacle provides little opportunity to participate other than by looking, photographing and acquiescing. Such limited space for interaction appears to inadequately address the central proposition of spacefaring that it is an endeavour for humanity, or even in service to a nation. The next chapter considers slippages in the state-citizen pact with space technologies whereby unprecedented forms of use and participation are achieved.

Chapter 4

A viewing of the spacecraft

The technography demands for a sophisticated imagining of the expansive, merging and conflicting affective realm of space technology enterprises. It is towards an apparatus for seeing the flexibility and expansiveness of such relations to which the thesis argument is incrementally moving. The technography presented in Chapters 2 and 3 plotted how the same spacecraft was used by various groups, such as mission scientists, public leaders, planners and museum curators and in so doing acquired different meanings. The focus now shifts to those whose relation to the spacecraft may, in Woolgar's words, be characterised as, "disaffected" (1998, p. 445). Finding a terminology with which to name this group is not easy. A terminology is needed that foregrounds both distance from the site of spacecraft production and distance from determining influence, while indicating also the unclear sense of opportunities for more direct participation that characterises this type of relation to the spacecraft. As a first step, reference to a specific group (e.g. the general public, laypersons, the common man) is replaced by that of a viewpoint. Viewpoint has the effect of always reminding of the idiosyncratic constitution of collectives. Viewpoint, it is argued, builds in a resistance to categorisation itself.

Rather than choose an expedient terminology a specific concern is raised through this chapter with the nature of what will be called the first-person viewpoint: The view from the perspective of "I" or "me". Describing the spacecraft through the properties of first-person views and experiences reveals an affective realm of the spacecraft that dissolves the boundaries set into the categories suggested by collective nouns such as humanity, public or society. An account based on viewpoint and experience allows for individuals to belong to more than one category, to dynamically change and also to be uncertain about their role and relationships. An emphasis is given in this chapter on seeing in order to foreground the constant shifts of a person's vantage point in their world and to accommodate the mobility of lived experience. This reduces the need for universalising categories to be applied to spacefaring and allows for the technography of the spacecraft to include perpetual interruptions to any kind of totalising account.[104]

What is provided in this chapter is an actual account of the spacecraft from a viewpoint mainly outside of the space agency and not connected to state or the production of state-endorsed media. From this viewpoint the spacecraft could be described through the analytical category of a 'cultural technology'.[105] It is not specifically available as a scientific instrument, or as an apparatus of state, but available for other usages defined through localised, temporal, individualised or collectivised inflections contextually applied. In this chapter a range of inflections that the term cultural technology gives allowance for will be unpacked. As a cultural technology, the spacecraft is characterised by its absence as an object: It becomes to a greater extent an imaginary or imagined object. What follows is a consideration of the (imaginary) presence of the spacecraft and its use as a cultural technology in a realm characterised by the overwhelming reality of the spacecraft's absence.

To explore this imaginary presence, another instrument, or probe, of sorts was used in the form of a socially engaged project called Moon Vehicle, led by the author. This project could be

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[104] Thie idea of interruptions to universalising accounts is considered in detail towards the end of Chapter 5 through the work of historian Dipesh Chakrabarty's (2000).

[105] The phrase 'cultural technology' has widespread use in discourse that addresses how technologies belong to cultural contexts. As such it denotes both uses intended by producers and the acquired meanings and uses of technologies that come about as technological meaning is negotiated within social domains. Celia Lury writes a chapter titled 'Cultural Technologies' in the book *The Sage Handbook of Cultural Analysis* (Bennet & Frow, 2008) of the term being used in discourses that address the affects of technologies on human nature and she considers the agency of humans and non-humans in these processes. Ron Eglash also gives a survey of theoretical perspectives that have emerged around the links between culture and technologies in his chapter 'Technology as Material Culture' in *The Handbook of Material Culture* (2006) on literature addressing the interpretation of culture through technology. He roots relevant discourses in social analysis such as that of Marx (1867), in social constructivism such as that by Pinch and Bijker (1987) and other frameworks such as feminist studies of Donna Haraway (1991) and actor network theory of Bruno Latour (2005). I use the term cultural technology at this point in the thesis to denote an encounter with the spacecraft that differs from those described in Chapters 2 and 3. Through the chapter I expand on how the uses of space technology that I draw from the Moon Vehicle interaction correspond with observations from critical discourse that engages with the notion of cultural technology.

called a cultural probe (Gaver et al., 1999) that through its activities gathered data,[106] which indicated the existence of some unaccounted for applications of space technology. The Moon Vehicle project began just prior to the launch of Chandrayaan in 2008 and was based in Bengaluru where the spacecraft was assembled. Its name is derived from the word 'chandrayaan', which although better translated as 'Moon chariot', encompassed the idea that the project would be a 'vehicle' providing a momentum by which the cultural resonances of the mission could be explored.

By preceding the introduction of this practice-based element of research with accounts of the workplace of the space agency and then an account of the mediating public-facing or state representations of the spacecraft, the practice and experiences of the Moon Vehicle project become restored within an overarching context and framework.[107] The framework given in the preceding chapters was not fully apparent to the participants at the time of the engagement. At the same time, the Moon Vehicle project was part of a continuum of experiences and interpretations produced by the Moon mission. The preceding chapters that addressed the experiences of the scientist-makers and the production of commentary and representations in publically available media, allows for flows and correspondences between different viewpoints to become more apparent.

While Moon Vehicle was in many ways unique and privileged in receiving time and resources through institutional support, it was not exceptional. Other independently organised creative

[106] The article by Gaver et al. titled *Cultural Probes* (1999) reports on a design methodology. The designers gave participants a collection of objects, which they called 'cultural probes', such as postcards, a camera and a map. The participants used or responded to the objects (probes) and their responses and dialogue formed the research data for the project. In the article this is described as an "artist-designer approach" in which the focus was not on a uniform methodology or analytical method but on "aesthetic control" (1999, p. 24) leading to "a more impressionistic account of their beliefs and desires, their aesthetic preferences and cultural concerns." (1999, p. 25). In a similar spirit, Moon Vehicle did not begin with a specific methodology, but rather used an aesthetic approach to reveal its subject, motivations and goals.

[107] This follows a methodological approach used by Diane Vaughan in her study of the causes of the Challenger accident (1996). In this study Vaughan traces preceding histories that provide a context for understanding the cultural norms of the space agency workplace that she seeks to understand. Without this background the decision-making of the space agency personnel appears negligent but with this framing context restored the decision-making of the space agency personnel makes sense. This method restores a frame of reference that gives meaning to otherwise inexplicable actions. In this thesis, placing the project in a wider context goessome way towards building the frame of reference of the participants by providing a sense of the context which was available and a sense of from where influences and information originated.

interventions into the space enterprises have taken place around the world.[108] Its study, however, illuminates a seam of curiosity, suspicion and resistance prevalent but largely invisible in the affective space of space technologies. Furthermore, it reveals a link between the use of the Chandrayaan spacecraft as a cultural technology and the agencies of viewing foregrounded by artistic practices. The Moon Vehicle project examined in this chapter provides evidence of aspects of the enterprises of spacefaring that are perennially missed blindspots in the full account of spacefaring. The project and its analysis here aim to give definition to missed components in the affective space of spacefaring.

The chapter is divided into two parts. In Part One is a description of the artist-led practice of the Moon Vehicle project and emphasises agencies of viewing, which includes tactics used in the project to gain access to the spacecraft so as to 'see more'. In Part Two the emphasis is on the motivations that led to the project, which reveals factors that impinge on the agencies of viewing already discussed. It is argued that the artist-led collaborative approach used in the Moon Vehicle project foregrounds how seeing and looking have a dependency on motivations and opportunities. Viewpoint can mean opinion, bounded by and subject to what can be seen and known yet also constantly in shift. Viewpoints are emergent from situations and change with the viewer's mobility and sensibilities. What is seen – and seeing itself – changes over time (Jay, 1988; 1994), is subjective (MacDougall, 1995; Bal, 1996; Rose, 2001; Mitchell, 2002;) and constructed through discourses (Mitchell, 1994; Cosgrove, 2001; Guha-Thakurta, 2005), technologies (Haraway, 1991; Baudrillard, 1994; Berland, 1996; Abraham, 2000) and institutions (Foucault, 1977; Mirzoeff, 2011) besides being culturally emergent (Barthes, 1957; Debord, 1967; Babb, 1981; Pinney, 1997; MacDougall, 1998, Kaur, 2003), gendered (Berger, 1972; Pollock, 1988; Mulvey, 1989) and perceptual (Merleau-Ponty, 1945; Gombrich, 1956). Viewpoint can shift as much through geographic mobility as through circumstantial, intellectual

[108] The symposium on Space and Society held at the International Astronautical Congress each year is a forum for many artist-led projects connected to spacefaring. The recently formed Technical Committee on the Cultural Uses of Outer Space (ITACCUS), has become one of the committees of the International Astronautical Federation is another forum where artistic, educational and other kinds of creative interventions are discussed and shared. Other creative interventions include the Palestinian Space Agency, the Brazilian originating Movimiento Sem Satelites (MSST) and the collective Orbitando Satelites that formed around a workshop event in Laboral in 2011. The enthusiast's hobby of sending weather balloons into suborbital space with video cameras attached could also be considered as a part of this zone of private, creative intervention.

or creative transformations in which cognitive shifts in opinion (subjectivities) take place. Agencies of viewing are therefore manifold and in developing those agencies through the visual and experiential capabilities to which artistic practices often lend themselves, myriad and unexpected uses and appropriations of space technology emerge.

In this chapter the technography is extended again and the Moon Vehicle project is used as a lens through which to look at the spacecraft in a third iteration.[109] It follows on from the viewpoint considered in Chapter 2 of the spacecraft from the position of the scientist-makers and Chapter 3 that considered the spacecraft through its mediated representation. Chapter 5 then considers whether what emerges from the technography is an awareness of subaltern viewpoints, expanding on a metaphor of optics used in subaltern historiography. This move suggests that the participants of the Moon Vehicle project, whether artists, children or scientists, became subalterns as they refocused their activities onto the aesthetics of the mission: A form of subalternism mobilising radical agencies of viewing. The final chapter then focuses on how aspects of visuality foregrounded through the artistic practice adopted through Moon Vehicle constitute a significant analytical tool in the study of space technology by highlighting both a subaltern aesthetic and the imaginative capability of capturing a 'technographic picture'.

[109] The technography, while an approximate analytical tool, nonetheless establishes how Chandrayaan mobilises a domain of affect to which the lenses of 'viewing', 'seeing' and 'looking' further activate and call attention to the subjectivities of that domain. In this chapter it is the viewpoints of the participants of the Moon Vehicle project that form the focus. Yet, those viewpoints are themselves for the most part elusive as becomes apparent in the analyses of drawings made during the project. Discourse from visual studies and visual anthropology problematises any assertion that the viewpoints of others can be known, represented or made available for analysis. See for instance essays on ethnographic filmmaking and photography by David MacDougall and Faye Ginsburg in *Fields of Vision* (Devereaux & Hillman, 1995). MacDougall, an ethnographic filmmaker, questions in his essay 'The Subjective Voice in Ethnographic Film' asking whether when 'subjects' become filmmakers (and take the place of the ethnographic filmmaker) their viewpoints become better conveyed. Since writing this essay he embarked on projects with children in which he taught them to make their own films. Some of these experiments were in India and MacDougall presented the new films that were filmed and produced by children at Srishti in November 2013 and discussed with the Project Vision research group and myself the nature of the subjectivity produced in the films using this method of filmmaking. In these discussions, the inescable trace of the 'foreign' eye came under scrutiny when MacDougall intepreted the way a boy filmed a new bride who became part of a household as a sign that he was 'in love'. To this, Project Vision researchers, who themselves had been 'new brides' in households, retorted that 'being in love' was an assumption and that children always had a fascination for and natural empathy for the 'new bride' who could be somewhat lost in their new surroundings. Both interpretations are arguably subjective interpretations – one seeming to 'exoticise' and the other to 'normalise' observed behaviour. In the context of the thesis such variations alert to the subjectivity of my own seeing and intepretations present in this chapter.

Project background

To briefly describe the origins of the project, the idea for Moon Vehicle came from a closed meeting of the organisers of the Bangalore Space and Culture Symposium[110] held in November 2007 prior to the launch of Chandrayaan and in parallel with the major annual space conference the 58th International Astronautical Congress in Hyderabad. The symposium in Bengaluru was held at the National Institute of Advanced Studies (NIAS), an interdisciplinary research institute located within the Indian Institute of Science, which at the time was under the Directorship of former ISRO Chairman Kasturirangan (who had first announced the Moon mission). The idea for a symposium including space technologists, artists and theorists did not come from the former ISRO Chairman, but from an informal consortium including the philosopher of science Sundar Sarukkai, based then at NIAS, Geetha Narayanan the Founder/Director of Srishti School of Art, Design and Technology in Bengaluru, Roger Malina the astrophysicist and Executive Editor of *Leonardo*, Journal of the International Society for the Arts, Sciences and Technology and UK based art/science agency The Arts Catalyst[111] run by curator Rob Le Frenais and director Nicola Triscott. This informal consortium in effect was staking a claim for the place of the arts and humanities, or more broadly culture, within spacefaring enterprises.[112]

This claim related also to the interest of all these parties in forging ties between the arts and sciences as part of an emerging genre of collaborative 'art/science' projects.[113] The merging of artistic practice with the domains of science and technology can be broadly related to shifts from more isolated studio-based practices such as painting to more participative, outdoor and community-based, site-specific and relational practices. These shifts are traced by art critics

[110] Bangalore Space and Culture Symposium (2007). National Institute of Advanced Studies, Bengaluru, 29 September - 1 October.
[111] The Arts Catalyst was founded by Nicola Triscott (a scientist) in 1994 to work with artists on ambitious projects that engaged with, or 'catalysed', science in new ways. It is based in London, UK.
[112] Similar events had been held at other space industry conferences. An art/science symposium was held during the previous 57th International Astronautical Congress meeting in Valencia in 2006, which included presentations, installations and events. The following year in 2008 The Arts Catalyst organised an artists' symposium called Less Remote within the International Astronautical Congress meeting in Glasgow, UK. (This was helped by a reduced fee for artists, the full price being €500)
[113] Various terms for art and science collaborations or projects are found in publications, grant schemes and exhibitions. For instance the biomedical research charity the Wellcome Trust had a Sciart scheme between 1996 and 2006 that encouraged artists to develop work that merged with life sciences. Publications such as Stephen Wilson's *Art+Science Now* (2010a) indicate a range of practices and terminology, for instance Bioart is used denote practices that cross into the field of biological sciences.

such as Nicolas Bourriaud in his book *Relational Aesthetics* (1998) but are complex and wide-ranging in origin.[114] Such a polemic combination as art and science is not unexpected though in the field of art practice and corresponds with other kinds of counter-intuitive creative strategies used by artists to generate insights. For instance, in her seminal article, 'Sculpture in the Expanded Field' (1979) the art critic Rosalind Krauss notes that sculpture has changed, or expanded, in that artists seem no longer to be creating sculptural forms but the inverse – spaces and voids – and she writes, "In this sense sculpture had entered the full condition of its inverse logic and had become pure negativity: the combination of exclusions" (1979, p. 36). At some level, an attraction to an inverse also underlies the moves by artists into the domain of science and technology: an apparent opposite. In some ways such shifts in art practices reflect also a discontentment with the emphasis on the market value of art-making and a wish by artists and others to integrate art-making into social and environmental structures, thereby regaining a spirit and meaning being lost in the commodification of art (Gablik, 1984; 1994). More pragmatically, art/science practices can be related to the funding structures that support them,[115] which in turn

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[114] Bourriaud describes the practices of artists, which he sees as constituting a new movement in art because the artwork requires a new form of active participation from the audience. Rirkrit Tiravanija for instance made food in galleries and saw the artwork as the act of sharing food with visitors. Bourriaud's claims have been criticised by Claire Bishop (2004) who argues the participative claim is a misunderstanding of existing forms of cognitive participation required by artworks. (Artist Liam Gillick (2006) whose work is also championed by Bourriaud in turn counters her critique.) In terms of the artistic approach adopted in the Moon Vehicle project by the author, the kinds of practice described in these debates on participation remain practices contained within art galleries and held within the frameworks and timeframes of exhibitions and form a background. They are important references nonetheless, indicative of both a legitimisation of participative practices and a shift away from the centrality of the artwork as object and towards the activity of being an artist in a social setting. A theorisation that is more empathetic with Moon Vehicle is in Suzi Gablik's article 'Connective Aesthetics' (1992) which forgrounds de-institutionalised practices. Importantly, for the notion of the 'artist' and 'artistic' put forward in the present thesis, she relates new modalities of art practice to shifts in perceptions of selfhood: "Such relationships require a consciousness that is different from the structural isolation and self-referentiality of individualism. In the post-Cartesian, ecological world view that is now emerging, the self is no longer isolated and self-contained but relational and interdependent" (1992, p. 4). In this article she laid the ground for her subsequent book *The Reenchantment of Art* (1994) in which she writes in a hopeful way about art practices that solve real world problems. She describes artists work co-creatively motivated by shared values rather than careerist or monetary aims. In this way the book has a deliberate symetry with her publication a decade earlier *Has Modernism Failed* (1984) in which she writes far more bleakly about extremely esoteric and individualistic art practices (centred on the United States experience) that disconnect and isolate the practice of art making.

[115] Bronac Ferran, who was an Arts Council officer for Interdisciplinary Arts in the UK till 2007 gives a good account of how funding for art and science collaborations emerged in the UK in the mid-nineties in her paper 'Creating a Program of Support for Art and Science Collaborations' (2006).

have emerged alongside the participation agenda associated with the public engagement with science.[116]

The Bangalore Space and Culture Symposium was not the first time an attempt had been made to forge ties between the arts and space. An art/science symposium was held during the previous year's 57th International Astronautical Congress meeting in Valencia and the international journal of art and science *Leonardo* had been a forum for many years for a developing discourse of art/science. TheMoon Vehicle project therefore relates to a lineage of art/science practices,[117]

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[116] For a survey of the origins of public engagement in the UK see Gregory and Miller (1998). There is an indepth discusssion of public engagement in relation to democratic process, policy and science in the work of political scientist Oliver Escobar. In 'The Dialogic Turn: Deliberation for dialogue' (2009) he examines the opportunity for dialogue within democratic process by bringing together theoretical studies of deliberative process with more grounded approaches to communication. This paper seeks to counter the inadequacies of positivist approaches to guaging public opinion via quantitative and statistical methods and moves to more interpretive methods of analysis that incoporate participative research. In a subsequent paper in 2010 (written with Magda Pieczka) 'Dialogue: Innovation in policy making and the discourse of engagement' the focus shifts to science policy in the UK between 1995 and 2005 and the interface between science and society. Here the tension between altruistic public engagement and its manipulation by business interests is clearly a cause for concern and Pieczka & Escobar conclude: "It is difficult to anticipate whether the gap between scientific and normative reason (Fischer, 2009) is about to be slowly bridged through democratic processes or steadily managed by technocratic means" (2010, p. 16). In my reading of such debates and discourse about public engagement and science communication I have noticed how approaches in this field have two key drawbacks: One is that they have a tendency to reify differences between science and society even when such divisions are being critiqued; Secondly, the research approaches seemed simply to close down a research imagination that arguably needs opening up to a richer set of ideas. My own contribution to such debates does so by circumventing much of the discourse of this area in order to find a fresh way in, which I do via the reflexive and heuristic analysis of the Moon Vehicle project presented in this thesis and the use of theory more closely linked to an experience in India.

[117] This lineage can be related to broader shifts in art practices (Bourriaud, 1998; Gablik, 1995; Krauss, 1979). Another, closer set of relations can be traced through schemes and publications that address practices bridging arts and sciences. This includes the establishment of The Arts Catalyst in 1994, the Sciart grant scheme of the Wellcome Trust in 1996 in the UK, The artists lab SymbioticA by Oron Catts and Ionat Zurr (formerly the Tissue Culture and Art Project) in 2001 in Australia, as well as publications such as *Strange and Charmed: Science and the contemporary arts* (2000) by Siån Ede; *Structural Intuitions: The Nature book of art and science* (2000) by Martin Kemp, *Art and Science* (2005) by Siån Ede, *Art + Science Now* (2010) by Stephen Wilson. Also commentaries on the emerging process of new initiatives including a *Leonardo* Special Section on art and science collaborations in 2006 with an introduction to funding schemes by Bronac Ferran and an article by James Leach on evaluating these interactions (2006). James Leach is a social anthropologist who was the attached observer to a number of projects in the arts/science research fellowships programme funded by the Arts Council UK. His writing about such collaborations include ''Being in between': art-science collaborations and a technological culture' (2005) and 'The Self of the Scientist, Material for the Artist' (2011) also published as 'Constituting Aesthetics and Utility: Copyright, patent and the purification of knowledge objects in an art and science collaboration' (2012). Siån Ede's commentary (2002) also gives background on the process of funding and emergence of a new art/science field of practice. The online bibliography accompanying Stephen Wilson's book (2010c) is good resource of artistic practice engaged with science. The series of publications documenting the Artists in Labs project in Zurich, Switzerland is also a useful resource that emphasises the experiences of collaboration (Scott, 2006; 2010).

More significant though are the art/science practices emerging at Srishti school itself. Geetha Narayanan (the Founder/Director of Srishti) instigated art/science residencies at Srishti as a way of developing highly experimental art projects that would feed into the undergraduate curriculum, keeping it energised and contemporary as well as issue-led rather than process-led. The year before my appointment which help elucidate why a consortium with an artistic bias sought to intervene into the predominantly science and technology led Moon mission. In a commentary in *Leonardo* about the role artists could take in relation to science and technology by Sundar Sarukkai, one of the organisers, cautions that in such moves artists can themselves become technocrats merely using and supporting existing systems without critically opening them up to other uses and users and he suggests, "One [approach] is to bring the discourse of beauty into that of technology, thereby expanding the vocabulary and image of technology. As we well know by now, the way we talk about something can actually fashion that thing" (Sarukkai, 2004). It can be inferred from this that many paradoxes lie in such a seemingly beneficent move of the arts and humanities towards the sciences. Nonetheless, the move of artists towards the domain of science and technology has much in common with other shifts led by artist practitioners to integrate creative practice and artist-led reflectivity into a wide range of cultural contexts. The use of non-traditional mediums (such as the Internet or sound) and non-traditional contexts (such as the science lab or the street) favour interventions into the practices of the everyday (de Certeau, 1984) and resists the segregation or institutionalisation of art. Such interventions also produce surplus effects. Placing critical questions within specific contexts and merging the relation of artist, artwork and audience, unexpectedly provided a means of solving problems difficult to reach by other methods. Problems identified at the interfaces between science and publics have been one of these problematic areas for which artistic approaches have been identified as providing solutions.[118]

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the artist Yashas Shetty began a residency in collaboration with the National Centre for Biological Sciences in Bengaluru (NCBS). The curator and director of The Arts Catalyst had also visited and curator Rob La Frenais held a six month curator-in-residence appointment. These appointments were made as part of the establishment of the Centre for Experimental Media Arts within the School, funded by the Sir Ratan Tata Trust. The 2007 Bangalore Space and Culture Symposium was one of the initial projects of the centre. This was followed in March 2008 with a workshop on Bio Art led by artist Oran Catts of the Symbiotica (an art/science lab based in Perth, Australia), which was the first of its kind in India. Artist/performer and filmmaker Shabnam Virmani's Kabir project at Srishti was also an influence on the participative, generative nature of the Moon Vehicle project as was the pedagogical research being conducted by the Project Vision research group at Srishti. There was a complex convergence of factors from which Moon Vehicle emerged and not all of these related to art or to science, but also to pedagogical imperatives.

[118] The recent implementation of 'STEM to STEAM' (Science, Technology, Engineering and Math to Science, Technology, Engineering, Art & Design and Math) is indicative of a growing recognition of the role of artists and creative practice within the discourse and practice pertaining to science and publics.

At the Bengaluru Space and Culture Symposium, it was noted that the intended merging of the scientific and artistic communities had not been as successful as was hoped and that a different kind of intervention was needed.[119] So at the closed meeting of the arts and humanities organisers it was decided that the Moon Vehicle project would be an artist-led mechanism by which the integration of the sciences and arts could be more fully developed using the launch of Chandrayaan as a focus. Moon Vehicle was based out of and funded by the Srishti School of Art, Design and Technology through a grant from the Sir Ratan Tata Trust. The first announcement of the Moon Vehicle project referred to it being, "a method of transmitting the cultural and philosophical meanings of the moon in India's culture" intended to, "initiate a dialogue about the public perception of space exploration in an Indian context".[120]

Shortly after, the author was invited to Srishti as artist-in-residence to mentor the Moon Vehicle project.[121] Beginning with a series of small-scale events and interventions, the project continued over two and a half years leading to a ten day festival of astronomy in December 2010 organised collaboratively between Srishti School of Art, Design and Technology, the Indian Space Research Organisation (ISRO), the Indian Institute of Astrophysics (IAA), The Jawaharlal Nehru Planetarium and the Visvesvaraya Industrial and Technological Museum. In terms of its originating remit to forge connections between the arts and sciences this jointly organised festival, with the title 'Kalpaneya Yatre: Journey of Imaginations', provides evidence for the success of the project in forging integrated links between scientists and artists and between institutions of astronomy and cultural or everyday meanings of cosmos.

The ethos of the project was to engender a sustained dialogue about the mission by developing a network of interest through projects that were participative in nature. A diagram created in the early stages of the project by the author (see Appendix 1) indicates the scope envisaged which included investigating the science and technical solutions of the mission, cultural and religious

[119] Anecdotal reports from participants from the arts community were that ISRO scientists attended presentations by ISRO Directors but did not stay for the artist presentations. However, my subsequent conversations with ISRO scientists indicate that the symposium did develop interest about connections across arts and sciences.
[120] This appeared in a draft document circulated by curator Rob La Frenais and sent to me in an email correspondence in February 2008.
[121] A more detailed background to my appointment as artist-in-residence and the scope of the project is given in the Preface.

associations of the Moon, visits to installations such as the launch site at Sriharikota and the Deep Space Network at Byalalu and the generation of a network of interest that would include families of ISRO personnel alongside those of the Srishti community. The network would therefore be cross-institutional, but also as far as possible de-institutionalised, reflecting the prevalent approach at Srishti for learning to take place in a variety of locations outside the institution and for 'communities of learning' to develop.[122] In effect the work of Moon Vehicle was to make evident the unexpected relevance of the mission beyond its anticipated user groups of scientists and academics and beyond the stated rationales of the mission. The Moon Vehicle project did not aim necessarily to encourage youngsters into the fields of space science in the ways stated for instance in ISRO's public outreach literature (see Chapter 3), but rather to create evidence that the Moon mission was relevant to many other kinds of disciplinary and non-disciplinary contexts, not recognised from the vantage point of the space agency and state.

The Moon Vehicle project consists of layers or overlapping stages. One of these layers is characterised by a search for the raw material behind the available public-facing media and information. A second layer is characterised by the construction of new information and accounts through forums devised and led by the Moon Vehicle team. A third layer is characterised by the co-creation of events and public-facing media jointly led by a mixed constituency of scientist-makers, art and design students and professionals, children, science popularisers and amateur astronomers. These stages to some extent follow sequentially, with the search for raw material followed by a production stage followed by the more consolidating stage during which a major astronomy festival was co-organised by the science and art institutions. The first two stages will be considered in some detail in this chapter in order to

[122] Artist residencies at Srishti School of Art, Design and Technology were adopted as 'vehicles' for exploring pertinent issues and for developing relevant, innovative methods and focuses that also brought together what were referred to as 'communities of learning'. In this way the institution became enmeshed with an extended, non-academic and diverse range of communities and situations, preventing the institution as far as possible from becoming self-contained. This outlook fits into a design education paradigm in which design students are trained to develop solutions for transdisciplinary problems, in which in many circumstances it is not so much the design of products that is taught, as designing for interactions. The methods adopted by the Moon Vehicle project linked very easily to such design thinking methodologies and the kind of project it became over an extended period of time. The forms of interaction used in the course of the Moon Vehicle project have a strong relation to emerging participative design methodologies such as discussed in Gaver et al. (1999).

move to defining some characteristics of the artistic approach adopted that include the co-creation of events and presentations. The collaborative staging of the festival is in part a resistant move indicating a wish on the part of mission scientists to dislodge the state's (fetishistic) purloining of the apparatus of rockets, spacecraft, antennas and to reinstate the science of multiwavelength astronomy as the societal gift of the mission. This indicates that subordinate positions could be found both at the peripheral zones of the enterprise and at its most proximal zone – within the space agency itself. Developments that took place over the course of the Moon Vehicle project are indicative of a shared intention to reclaim the representation and public presentation of the spacecraft and its mission.

Part One: Seeing Chandrayaan

The emphasis put on seeing in the next section foregrounds the visual alacrity of the Moon Vehicle project, which is further expanded in Chapter 6.[123] Seeing is used here as a heuristic that emphasises experiences of seeing, looking, searching for and finding the spacecraft Chandrayaan. The concern here is not with the optics of seeing or with perception, but with subjectively informed patterns of seeing, modulated and enhanced by creative visual production such as drawing, making and performing that enabled a deepening interpetive engagement with the spacecraft. The heuristic of seeing is linked in the second part of the chapter to anxieties that motivated the project. Here, theoretical perspectives on hidden forms of governmentality indicate that seeing equated with exposing or making such hidden influences visible. The visual

[123] Much of the work I devised was intended to promote dialogue, conversations and encounters. A fuller description of the project might have developed all three themes – seeing, dialogue and encounters – as all were related. I have chosen to describe the project in relation to seeing in order to develop later the proposition of 'the technographic picture' as a key contribution of the thesis. However, 'seeing' also encompasses the capacity for dialogue and encounter as in the notion of being 'face-to-face' and in the same physical space. Sight also provides evidence, as in the phrase 'seeing is believing', as such seeing relates to the ease or difficulty of acquiring access to forms of knowledge for which seeing enables understanding. The theme of 'seeing', taken as a methodological approach in this section, is a heuristic for testing access, both the negotiation of access to actual spaces (ISRO sites) and cognitive spaces (science and technology as disciplines). It also demonstrates how new spaces (actual and cognitive) were created simply as a result of the attention paid to the Moon mission through the activities and interventions of the Moon Vehicle project. The discussion of modalities of seeing is developed in Chapter 6.

art practice developed through Moon Vehicle was thereby an act of resistance exposing forms of cognitive control accompanying ISRO's space missions.

The search for raw material

This section addresses the initial efforts of the Moon Vehicle team to see behind the public-facing media about Chandrayaan and highlights means of access to the spacecraft that were readily available and other means of access that had to be found more resourcefully. In this way the surface availability of Chandrayaan is considered together with its less accessible dimensions. Attention is drawn to the relation of this 'seeing' to geographic, social and disciplinary mobility as well as to imaginaries. The process of seeing Chandrayaan involved many kinds of resourceful fieldwork in order to build up a full sense of what the spacecraft and what a Moon mission entailed. To see in the broadest sense meant understanding many aspects of the mission - its scientific, technological, political and economic aspects - in order to build a credible and informed response through poetic, creative and aesthetic methods. The artist-led project of Moon Vehicle provided an opportunity to respond to the mission by accessing such a transdisciplinary[124] range of methods, knowledge and contexts. This involved accessing raw material rather than the secondary information provided in the publications, images and commentaries outlined in Chapter 3. Finding the originating sources of such media, including visiting the highly secure work premises of the space agency, required resourcefulness and inventiveness.[125] The best way to access a rich understanding of the unmediated spacecraft

[124] Nowotony, Scott and Gibbons define the modality of transdisciplinary research in their reflection on Mode 2 knowledge production (2003). Mode 2 supercedes or is in tension with a more recalcitrant Mode 1 discipline-specific field. It is described in a way that closely fits the modality of Moon Vehicle, "Characteristically, in Mode 2 research groups are less firmly institutionalised; people come together in temporary work teams and networks which dissolve when a problem is solved or redefined." Significantly they suggest that such mixed and informal working groups acquire specialist knowledge through their very alterity, "The experience gathered in this process creates a competence which becomes highly valued and which is transferred to new contexts. Though problems may be transient and groups short-lived, the organisation and communication pattern persists as a matrix from which further groups and networks, dedicated to different problems, will be formed", (Nowotny, Scott and Gibbons, 2003, p. 6)

[125] Carol Upadhya's article (2008) on accessing high tech companies in Bengaluru to carry out anthroplological research echoes the need for resourcefulness in conducting research within restrictive environments. Her research need to "follow and allow the field to define itself" proved difficult and she found that by suggesting to the company that she needed to produce an ethnographic film, gave her the

seemed to be to build a direct connection with the spacecraft via its mission team. The terms of this access relate to the seeing of Chandrayaan and as such can be thought of as components of an optical problem in which not being able to see the spacecraft diminished participation in the Moon mission.

In the first few weeks of the Moon Vehicle project four students visited the ISRO Satellite Centre, Old Airport Road, Bengaluru where they saw Chandrayaan being assembled in the clean room through the glass of the visitor's gallery. On their return they gave the following eyewitness account, which indicates in its gaps and confusions some paradoxes of seeing the spacecraft.

> S: And you could see into this room, yellowish, huge room with all kinds of cranes and stuff on top and *Chandrayaan* was in one corner of it, and the scientists they were wearing these sort of caps and gloves and gowns and sort of working on it on one table sort of assembling it together.
>
> J: And how big is *Chandrayaan* and what did it look like?
>
> S: It was...didn't look impressive at all, it was just a black box
>
> G: No, I think it was very much in the initial stages of its assembly process
>
> B: Once the payloads had gone in they still had to put the thermal blankets,
>
> J: But I mean is it as high as a person, or small like a bag?
>
> S: No, no no, higher, the height of a room,
>
> G: See the rocket that will take it up there is the height of this building,
>
> B: Wasn't it just this much?
>
> S: Oh, it was also mounted, so we couldn't really tell, which was the mounting, which was the structure,
>
> B: No the black thing was the *Chandrayaan*.
>
> G: No, nothing was *Chandrayaan*, are you guys talking about the outer shell or,
>
> B: Ahh, outer shell,
>
> G: Yaa, yaa, that was this height, or maybe higher as well,
>
> S: OK, we are very confused about the height of *Chandrayaan*
>
> J: Ha ha, you don't know what it looks like do you?

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ruse to spend informal time with her research subjects, to "hang out" and absorb the complex circumstances in which employees worked, circumstances that interviewing did not reveal.

S: We don't know where it began. (Interview by the author with Srishti students, 2008)

Paradoxically the object in the clean room gave little sense of the spacecraft. The uncertainties over what was seen in the clean room, for instance the confusions around where the spacecraft began, points to a distance between the scientist-makers who designed the mission and the visitors who were uninvolved and lacking in knowledge and thereby a tangible connection to what they saw. Although the spacecraft could be seen, it meant little without the working knowledge of the production process distributed among the design and production workforce.

In a sense therefore the kinds of public presentation of the more coherent image of the spacecraft, described in the previous chapter, although falsified in ways, provided a better fit with an imagined image of a spacecraft, accessible without specialist knowledge. The raw view of the spacecraft, without the intervening cultural inflection provided by news commentaries or other representations presented an incomprehensible fragmented image that underlined the real alienation from this technology, which was not one of distance from the site of production so much as a gap in knowledge and experience. If representations of technologies are infiltrated and mediated in the public or cultural domain then in order to see the raw spacecraft in a meaningful way, the knowledge criteria of the clean room technicians and experimental scientists would need to be learnt. The viewers, in this case design students, would need to calibrate themselves to what they were seeing, by learning a new frame of reference.

In contrast, the Space Gallery in Bengaluru's Visvesvaraya Industrial and Technological Museum, which the Moon Vehicle team also visited, presented satellites and rockets exhibited within a kind of stage set mimicking the environment of space, providing a familiar non-technical public imaginary of what a spacecraft should look like. The same group of design students (along with the author) visited the curators of the Museum in order to find out more about Chandrayaan and also to discuss a possible joint project. At this early point in the project, which was before the launch of Chandrayaan, the Museum had not yet created its Moon mission exhibit, but the curators talked about their plans for how they would present the spacecraft. Their understanding of the spacecraft was guided by their interactions with staff in ISRO who assisted their research and decisions. The curators mentioned their conversations with scientists and visits to ISRO sites, which informed the design and production process behind the public exhibit.

The access the Moon Vehicle project team gained to the ISRO clean room and to the curators of the Space Gallery brought a less mediated more raw view of the spacecraft. This access was reliant in part on the social mobility of the Moon Vehicle team – the ability to demonstrate enough credibility to gain access into spaces beyond areas deemed to be publically accessible. The group was able to slightly differentiate itself from the other museumgoers, because the Museum curators were interested in working with the art and design students on new approaches. So it was that the group could walk through the public museum space, following the curators through a door rendered almost invisible by the exhibition design painted across it, into the monochrome corridors of the Museum's administration offices and learn from behind the scenes about the Space Gallery construction.

This move from foreground to background, from the public exhibit to the hidden offices, was repeated in comparable forms through these early weeks of research. The clean room visit for instance, was arranged through contacts made at the Space, Arts and Culture Symposium. The full story of the student's access to the clean room and to the museum curators could be traced through a number of encounters that had come about partly by chance and partly by design. Each new encounter had roots in gradual accumulations of meetings through which a network of contacts began to form. This gradual building of a network incrementally increased both the group's credibility and its access to the spacecraft. Besides shifting the outward perception of who they were in order to gain access to the spacecraft, the group found the spacecraft by actively moving through the city to different places and people. Encounters with the spacecraft took place through sites such as the Museum and the clean room, but also, and significantly, through the witness of others more closely connected to the actual spacecraft body. The 'seeing' of the spacecraft – without seeing the spacecraft – developed through a kind of game of geographic mobility and social mobility that was reliant on a network of close witnesses of the spacecraft through whom proximity to the technological artefact was gradually gained.

In a similar move to build a vicarious proximity to the spacecraft, a meeting was arranged with the astronaut (or more accurately 'cosmonaut') Rakesh Sharma. In 1982 Sharma had flown on a Soviet Soyuz craft and he lived and worked in Bengaluru. His daughter had studied art and design at Srishti, so making contact with him and explaining the group's objective was relatively easy. He shared his experience of orbital space, speaking of the eight minutes of violent noise and shaking of launch followed by complete silence and zero gravity. He talked of viewing the Earth from space and told the group that what he saw was not so unusual or different from what any of us might have seen already in photographs. He shared his opinion that India had launched a Moon mission in order to become part of a conversation with other Moon-faring countries, 'the comity of nations', which he suggested might be a, "sobering voice, in doing things differently" (interview, 2008). This encounter with the cosmonaut seemed relevant to the building of a picture of Chandrayaan because it brought the group a sense of proximity to both the actual experience of being in space and also to a surrounding discourse. Sharma seemed to have access to an overview of what the Indian space programme intended from Chandrayaan. He was a person who could see the Moon mission from a unique perspective encompassing his experiences as a test pilot for the Indian Air Force, through his training for spaceflight, his actual journey and then his subsequent status as a public figure and also an artefact from space. This gave his opinions credibility because he had the rare ability to discern the operation of government and of the space organisation ISRO, from an informed but independent perspective that included the ineffable quality of being a space celebrity, a status he shared with the spacecraft Chandrayaan.

This interview with the astronaut, the visit to the clean room and the foray behind the scenes of the Space Gallery to meet the curators and glimpse what lay behind the construction of the public facing exhibit, were portals of a kind by which to access space and the spacecraft. They were places of possible connection. The process of research was in some ways one of excavation, of finding the spacecraft within locations and within the experiences and accounts of certain people. These direct encounters with places and people seemingly began to draw a path to the spacecraft itself, but in the process also marked out a map or landscape of associations that the spacecraft at the Moon called attention to. This included archival documentation of the Apollo missions and records of the many other Moon probes, which the Moon Vehicle team also researched. The spacecraft was an element in the *dispositif*[126] of the Moon mission and the much broader associative realm of the Moon mission not only with interplanetary exploration but also with profound cosmological questions.

The construction of accounts of the spacecraft

The ways that the spacecraft tapped into a broader associative realm was more pronounced during Moon Vehicle events and workshops. The second stage or layer of the project (which also overlapped with the first stage iteratively) is characterised by the construction of new information and accounts through forums devised and led by the Moon Vehicle team (see Panel 9). In the first workshops, which were for children (11-12yrs), an image of the Moon was projected onto the floor and the children crammed around the edge of the image to paint and draw freely (Panel 9, Figure 26). This resulted in colourful and anarchic images of many kinds of monstrous depictions and a stream of popular culture that the children painted onto the Moon. The session also resulted in photographs of the children in action painting the Moon, which, with only their hands illuminated, evoked certain conflicts inherent in the Moon's future: The unresolved issues for instance of how its landscapes might be further disrupted by human interference and who would and would not be a part of determining such futures. In the context of the project, the picturing called attention to issues at the heart of the Chandrayaan mission concerning responsibilities to complex issues of conduct, governance and cultural representation in interplanetary travel, while also giving evidence of the substantial associative imaginaries of spacefaring.

[126] The term 'dispositif' used by Michel Foucault to indicate both apparatus and relations (of a socio-historical nature) is a philosophical framework for understanding relations of power (Foucault, 1980). Foucault had a particular focus on institutional and state apparatuses such as schools, hospitals, prisons and asylums and he sought to show how their material architectures structured and produced relations of power as social phenomena (Foucault, 1977). A significant element in the structuring of these architectures and relations of power was surveillance: a dynamics of seeing controlled by the institutional architectures.

Figure 26

Figure 27

Figure 26 shows children painting and drawing on an image of the Moon projected ont the floor during one of the first workshops of the Moon Vehicle project. **Figure 27** shows two children sitting on an image of the Moon projected onto the floor during the Moon Vehicle event called *100 Days of CHN-01* held at the Centre for Experimental Media Arts, Srishti School of Art, Design and Technology (photos: the author) (*Images reproduced courtesy Mallya Aditi International School and Srishti School of Art, Design and Technology*)

Subsequent events were designed to draw in a wider community to focus on questions the mission drew attention to. A Moon Vehicle event called '100 Days of CHN-01' was held on the hundredth day of Chandrayaan's mission, *CHN-01* being the mission shorthand for Chandrayaan. On this day all the teams of mission scientists from India, United Kingdom, United States, Bulgaria and elsewhere were gathering in Bengaluru to share their reports of the first data received from the spacecraft. Moon Vehicle organised an event on the same day and it was held on a rooftop at the art and design college. The event was a gathering at which a number of prompts and activities encouraged discussion and focus on the idea of Moon missions. The projection of the Moon image onto the ground was used again, but this time participants could sit on the Moon [see Panel 9, Figure 27]. At one point three participants, sitting on the Moon image, staged a read-through of a section from the Apollo Lunar Surface Journal transcripts in which a green rock was discovered. Others sat on the projected image and were videoed giving their thoughts about future human interactions on the Moon or their own sense of their relation to the Moon. The gathering included sky watching, provided by the curators of the Technological Museum, food, drink and music.

The prompts and activities brought to mind the surface of the Moon and a perspective of seeing from the Moon. The literal immersion involved in putting oneself into the projected image of the Moon, almost corresponded with the observational position of the Chandrayaan spacecraft, by then close by the Moon and visually subsumed into its surface. The event was primarily a way of sharing the new project with the staff and students of the art and design college community. However, an invitation to the Moon Vehicle event '100 Days of CHN-01' was sent to the scientists at the Chandrayaan meeting and the invitation was projected as a PowerPoint slide during the meeting of the international teams, to make them aware of the event and the invitation. Although none of the scientists were able to attend, by offering the invitation they became aware that there was a parallel spin-off project in process. Having the event publicised at the meeting gave the Moon Vehicle project a profile, which meant that it was easier to subsequently arrange informal meetings with the visiting mission teams during their stay in Bengaluru. Some of the Moon Vehicle students met with the team from the United States in their hotel to find out about their instrument the Moon Mineralogy Mapper also called M^3. Another meeting was arranged with British and Indian scientists of the Chandrayaan-1 X-ray Spectrometer instrument also called *C1XS* (pronounced "kicks"). The artist-led project thereby generated a hybrid community and network across which, retrospectively, an accent can be placed on viewpoints, including the viewpoint from the Moon, from the spacecraft, of the mission teams, of the curious citizen, of the artist and of the telescope.

Within the conversations with mission scientists lay further access to the surface of the Moon, as the scientists who had been researching the Moon, some for twenty years or more, talked with familiarity about places on the Moon and events from its past. One such event related during these conversations was that at one time in the Moon's history there had been giant fountains of glass. As the liquid glass cooled and oxidised during its slow projectile motion it formed beads of orange glass, which fell in radial strings across the Moon's surface. It became evident during these informal conversations with Chandrayaan's mission scientists that took place in cafés and hotel lobbies, that the surface of the Moon, its topography, geology and landscape history was carried in the imaginations of these particular networks of scientists. This insight into the landscape of the Moon through the testimony of the lunar scientists of the Chandrayaan mission, made evident the role of spacecraft and its instrumentation in the formation of a collectively held and collectively constructed imaginary of what the Moon was. Through conversations the surface of the Moon could be accessed and re-distributed, like data from archives, of detailed accounts built up through research careers and held as imaginative constructs of knowledge by the lunar scientists.

The scientific method of seeing the Moon's landscape via a spacecraft gave access to an imagined experience of the landscape, built up over time, without direct experience, but with what could be thought of as secondary forms of direct experience.[127] Seeing the Moon through the testimony of these scientists who had constructed their own particular landscape views of

[127] See Janet Vertesi's dissertation *Seeing Like a Rover: Images in interaction on the Mars exploration rover mission* (2009) in which she provides extensive evidence of the connections made between the team of operators and the Mars Rovers, including how the teams use their bodies to mimic the actions of the Rovers as they talk about them, to deeper senses that they *are* the Rovers. Vertesi's research has implications for discussions of affective computing, distributed technologies and the distributed person.

the Moon via instrumentation that they themselves had built and through data they themselves had synthesised, became a way of seeing the Moon, without seeing the spacecraft. Listening to these informal conversations rendered the instrumentation invisible. Instead the scientists themselves became the medium of interpretation, subsuming the technology, which they themselves had anyway constructed. Compared to looking at the spacecraft in the clean room, here in these conversations was access not to the spacecraft but to its viewpoint. This looking at the Moon through the scientists' oral accounts, who were seeing through the instrumentation of Chandrayaan, provided a view at the distance of the spacecraft of what the spacecraft saw. But as the spacecraft has no view or experience itself, but rather a central void of experience, it was this seeing via anecdotes and reports that effectively constituted the Moon Vehicle group's seeing and experience of the spacecraft.

The production of visual artefacts

A number of Moon Vehicle workshops were held at schools with middle-school children (around the age of twelve) for which students from Srishti worked with the author to devise and deliver creative learning projects.[128] These also involved scientists from ISRO and the Indian Institute of Astrophysics (IAA). As such, the workshops were vehicles to bridge neighbouring communities of scientists and children living in nearby slum areas. One of these took place with children from Drishya Learning Centre[129] a school located in an urban slum close to the ISRO

[128] The Moon Vehicle summer school is described in the article in Appendix 2 (Griffin, 2012). The following year a second Moon Vehicle summer school (MV2) took place for two weeks and aspects of this workshop are described in the article included in Appendix 3 (Griffin, 2013a and 2014). Alongside MV2 another project began at Madivaala Government School that spanned two months. This invloved four days of workshops at the school (led by Deepak Srinivas) followed by field trips to the Indian Institute of Astrophysics and ISRO (arranged by the author). After these workshops I developed some of the work made by the children into large-scale bamboo lanterns, which the children helped construct. The lanterns were hung in the trees and illuminated at night during the Kalpaneya Yatre: Journey of Imaginations festival in December 2010. The children held a procession one evening and we invited scientists from the Indian Institute of Astronomy (IIA) to participate and tell their stories of the spacecraft they worked on. In the event none of the IIA scientists appeared but three cosmologists from the Raman Research Institute joined the children and brought musical instruments and all sang songs instead of telling stories!

[129] Drishya began in 2002 as an education movement run by a Trust and is part of a wider social activist project to improve life in urban slums in Bengaluru. Geetha Narayanan (Founder/Director of Srishti School of Art, Design and Technology) together with her research group Project Vision developed its curriculum.

Satellite Application Centre in Bengaluru. The workshop was an intensive two-week 'summer school' and one of a number of workshops led by artists that were intended to give the children a different kind of exposure to the world around them through creative, experiential engagements (Mistry, 2010). In the first week of the Moon Vehicle summer school two visits were made to ISRO. The first was to the ISRO Satellite Application Centre where Chandrayaan had been assembled and the second to the ISRO Indian Deep Space Network (ISDN) 30 km south of Bengaluru where the huge tracking antennas were located and images from the Moon's surface streamed from the spacecraft each day. In between and in response to these activities the children discussed what they had seen in the context of scientific and non-scientific ways of knowing the Moon, adding their own invented mythologies and questions. They developed highly creative portfolios of drawings, fabricated their own spacecraft and every morning worked with a dancer (Anitha Santhanam) to develop performances based on their interactions with space technology and technologists [Panel 10]. At the end of the two week workshop the children presented their performances and creative work to an audience of other Drishya children and facilitators together with scientists from ISRO and the Indian Institute of Astrophysics.

In this important process of sociability across disciplinary domains, social divides and generations, the ineluctable accomplishment and ingenuity of the visual artefacts and performances produced by the children called attention to their interpretive and generative abilities that took the participant astronomers and space scientists by surprise. The expectaton that the scientists would teach the children was inverted to some extent and instead the children's creative work effectively explained back to the scientists the inventive and critical meanings the children developed themselves, through their creative transformations. The workshop emphasised ways that transformative creative processes established the value of the children's own experiences and viewpoints and in so doing appropriated space technology and its rituals of reception.

This appropriation had many facets and was a constant and iterative aspect of the workshop. After their visit to the clean room at the Satellite Application Centre for instance the children

Figure 28

Figure 29

Figure 30

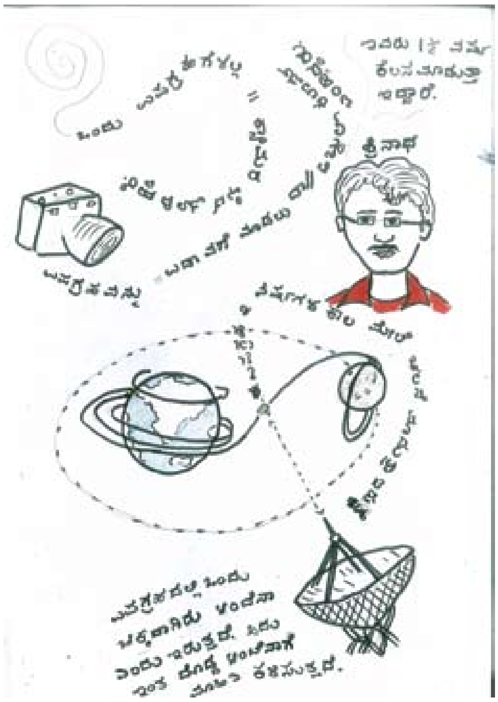

Figure 31

Figure 32

Figures 28-32 show drawings, performances and objects produced during a two week Moon Vehicle workshop with pupils at Drishya Learning Centre. The group visited two ISRO facilities, the Satellite Application Centre and the Indian Deep Space Network facility at Byalalu. **Figure 28** is a drawing showing the back of the 32 metre antenna and an operator interviewed at his workplace inside the antenna building. **Figure 29** shows a performance rehearsal in which the children form the shape of the antenna. **Figure 30** is a spacecraft model decorated with phases of the Moon. **Figure 31** is a drawing made at the Indian Deep Space Network that includes the scientist hosting the visit. **Figure 32** is a photograph taken from the edge of the site. Closer photographs are prohibited. (photos: the author) *(Images reproduced courtesy of Drishya Learning Centre)* began to build their own versions of spacecraft and, dressed as ISRO technicians, to some extent usurped the technician's role and accessed imaginatively the inaccessible zone of the clean room. Through their creative work the children further deconstructed the restrictions and social hierarchies which they had observed and been subjected to. Spacecraft and rockets with white coats and button down shirts appeared among their creations as well as drawings of military security guards ordering the children not to bring cameras, mobile phones or USB drives appeared in their portfolios and performances. The creative work negotiated a position of agency for the children, which in some sense was fleeting in that it was reliant on the context of the workshop. It was an agency that arguably brought no determining influence on space technology (Hart, 1992).[130] Yet, the performances and creative artefacts presented a space of interpretation in which the children re-ordered ISRO's space technology into schemes of their own devising. [131]

The viewpoint of a drawing

Some of the artwork produced provides clues to the nature of a viewpoint that enfolds the experience both of seeing and being seen. ISRO does not allow photographs to be taken on its sites, so to make a record of the visit to the Indian Deep Space Network the children were asked

[130] In some respects the workshop followed a pattern of showing children an opportunity to which in reality they may have little chance of entering because professional scientists in India, as pointed out earlier, are predominantly from the higher castes. At least one of the children wanted to become an ISRO scientist as a result of the workshop, but in order to do so would have to pass the necessary exams, besides negotiating extremely biased social hierarchies. In this respect, the creative transformations are, arguably, symbolic in the best case and in the worst case misleading aesthetic exercises taking advantage of vulnerable communities in order to make esoteric interventions. This critical point was brought home to me in a conversation with educationalist Binay Pattanayak who gave a presentation at the 13th All India People's Science Network Conference 2010 in Thrissur, Kerala. Pattanayak contributed to a report about learning for deprived children in India (Jandhyala & Vellema, 2007). See also Roger Hart's report for UNICEF (1992) 'Children's Participation: From tokenism to participation', in particular his "Ladder of Particpation" (p. 8) and Sofia Hussain (2010) 'Empowering marginalised children in developing countries through participatory design processes'.

[131] In one performance the Moon is being photographed by visiting spacecraft and likes the attention, cutting stylish poses as the spacecraft snap away. But then the Moon complains of being tired of all the attention and disappears. This, the performers conclude, is the reason for the phases of the Moon. This is an updated version of a well-known Ganesha story. Ganesha is the elephant headed god and his vehicle (most gods have distinctive animals as transport) is a mouse. In this story Ganesha falls over from overeating. The Moon laughs at him and so Ganesha makes the Moon disappear. When the Moon pleads Ganesha softens the curse so that it fades away for 15 days and then returns so the story explains the phases of the Moon.

to make 'interview portraits'. These interview portraits (Panel 10, Figures 28 and 31) were drawings made while interviewing some of the personnel on site such that the drawing illustrated how that person was connected to, or responsible for the various technologies, structures or systems depicted. In Figure 28 an operator working in the room underneath the 32-metre antenna is talking about how the antenna works, how he got his job and how much he is paid. In this way the drawings are not just illustrations of space technologies, but also records of encounters. The ban on photography, which is not unusual in space agencies, has the effect of reinforcing separations between the world inside the space agency and the world outside. ISRO alone controls what images of the interior spaces of the organisation reach the public domain. Drawings hold a comparatively benign status next to the photograph. In this context of a highly secure premises and an organisation that controls the production of images of its workplaces, for many understandable practical reasons, the relatively benign status of drawing becomes a loophole through which to look at ISRO in ways that gently subvert the controls on imaging enforced by the organisation. These processes of seeing are to some extent captured in the matrices of drawings, which include not only the image drawn, but the place in which the drawing was made and the person who was there. Drawings on or off site are traces of complex relations between the person seeing and what is seen. Revealed in this process are both the regimes of seeing and looking controlled by ISRO – the ban on photography, the perimeter fence allowing only glimpses over the wall, the ownership of Chandrayaan's cameras, the massive video projections of real-time streaming video from the Moon's surface inside the mission operations control room and banks of archiving hard drives – and, in counter-point to these collosal vision technologies, the regimes of seeing in the control of the child drawing with paper and pencil. The grittiness of interferences that shape the traces that drawings leave, begin to be clues whereby the merging of the self with the world becomes more apparent. John Berger writes in *Ways of Seeing* that, "we are always looking at the relation between things and ourselves" (1972, p. 9). If this is so then the drawing reveals a trace of this relation between things and ourselves. The drawing is an articulation of relations – social and affective relations

– obscured by the excessive visual performance of the technology,[132] which the drawing, as a record of an experience of seeing, deciphers and foregrounds

In a drawing shown in Panel 11 and made during the same two-week workshop, the left half of the page shows the three stages that the launch rocket separates into as it lifts off and travels into orbit. The spacecraft, carried in the nose tip of the rocket eventually leaves the rocket as is shown in the drawing. On its journey, Chandrayaan was pointed back towards the Earth to photograph the lunar eclipse and in the drawing the spacecraft is shown pointed at the Earth. The last two images in this sequence appear to show Chandrayaan in its orbit of the Moon. The information of this drawing can be related to that given on the children's visit to the ISRO Satellite Centre where the rocket stages and the process by which the spacecraft reaches orbit and traveled through space to the Moon were explained. The right hand side of the image presents similar kinds of information about the mission, but in a more idiosyncratic way, within a huge plant or flower. Written in the petals of the flower is the factual, but nonetheless poetic numerical information about the mission repeatedly told to the children during their visits to the ISRO Satellite Centre and the Deep Space Network - that Chandrayaan took 3 days to reach the Moon, that it took 3 years to build and that the cost of the mission was 300 Crores (a unit used in India, 1 Crore = 10, 000 000). There is the sense in this drawing of the kind of repetition of facts and diagrams familiar in school exercise books, but also of a current of remix and drift. There is in the depiction of the huge flower a sense of drift away from the dominating images of space technology. Instead the technological narrative appears subsumed into a narrative of the natural world.

[132] The notion of large, scientific apparatus in the landscape creating a visual performance is developed in an essay by Itty Abraham 'Postcolonial Science, Big Science, and Landscape' (2000) in which he draws on the idea of "spectatorial work" used by W.J.T. Mitchell in his chapter 'Imperial Landscape' in the book *Landscape and Power* (1994). Mitchell explores how things such as pictures or films require "spectatorial work" in that they are made to be looked at, whereas things such as scientific instruments appear not to be designed for aesthetic appreciation. It is within the apparent denial of visual affect that Mitchell suggests are new emergences of the imperialist relations that were evidenced for a time through the genre of 'landscape painting' may now be located. Abraham uses this suggestion to examine the affect of the appearance of large-scale scientific apparatus in the Indian landscape. The visual performance of such structures is a form of imperial power for which a specific type of spectatorship is required one that inevitably subjugates the non-scientist who is assumed to see without comprehending the purpose of the instrument.

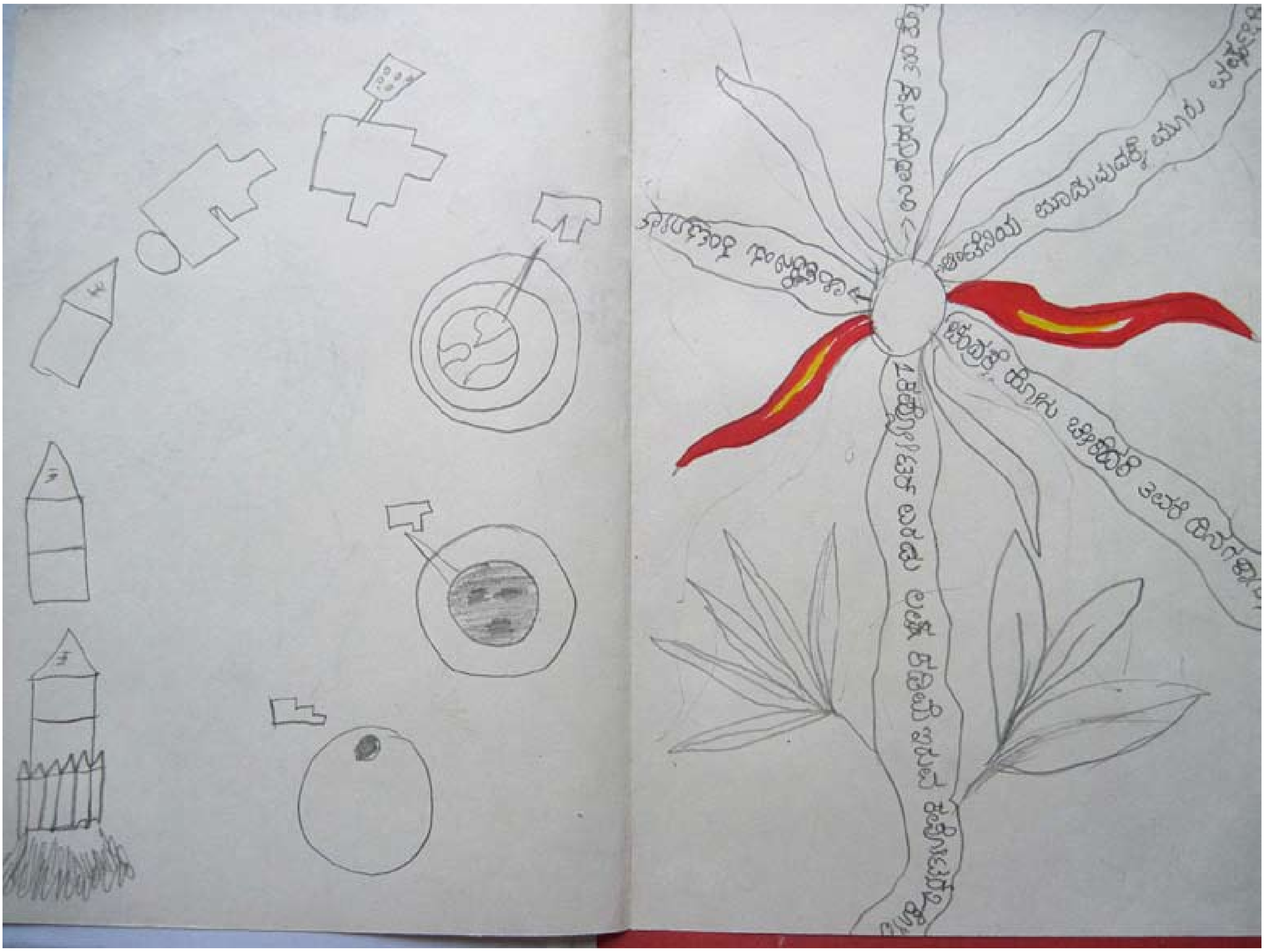

Figure 33

Figure 33 is a drawing made during a Moon Vehicle workshop by a pupil at Drishya Learning Centre. On the left hand page is a drawing of the three rocket stage launch of Chandrayaan and its journey to the Moon. On the right hand page is a drawing that looks like a flower. In the petals, the text (written in Kananda language) says that Chandrayaan took three years to build, took three days to reach the Moon and it cost 300 Crores rupees (1 Crore= 10, 000 000). (photos: the author) *(Image reproduced courtesy of Drishya Learning Centre)*

The antenna dishes were described to the children as "like the petals of a flower" so the drawing could be interpreted as a 'mistake', a misunderstanding of what was meant by the scientist's analogy.[133] Similarly, in writing that the mission cost 300 crores, there is a discrepancy in the spelling and what is actually written is the word for 'forts' which is very similar to the word for 'crores'. It reads "300 forts of satellites", although it might be assumed to mean "300 crores of satellites".[134] The intentionality behind the writing and drawing is difficult to guage. Instead the apparent mistakes are glitches that draw attention to an ether of mediation between seeing, description and interpretation. The 300 forts or castles of satellites and the plant-like antenna are alluring concepts yet the meaning this had for the child making the drawing is elusive. A drift is detectable in the drawing though, and, to an extent, a recontextualisation that constitutes an act of authorship.

In another drawing on Panel 12 (Figure 37) the mediation of other available images is more pronounced. The image to the left of the page of a spacecraft orbiting the Moon is a fair rendition of images the children received from ISRO on their visit (Figure 36). The other Moon-like figures with arms and feet seem unaccountable, yet similar rockets and spacecraft with arms and legs are used in an ISRO publication (Guruprasad, 2009) which the children also had access to (Figure 35) and an image cut out of a mobile phone advert of a computer with arms and legs had been used by another child to decorate their portfolio (Figure 34). The drawing in Panel 12 may be derivative in its origins, but the resulting drawing is not. It is something new. It holds the viewpoint of a person in a particular time and place.[135] It gives access to the knowledge that this particular child's viewpoint was articulated, drawn and viewed by others. The level of

[133] In a press conference given for the Kalpaneya Yatre: Journey of Imagination festival of astronomy in November 2010, the ISRO Public Relations officer described the 32 metre antenna dish as being like the petals of a flower. When I was with the children at the Indian Deep Space Network the language used was Kannada and I had not then realised that the dish was described in this way.

[134] Madhava Chippali, (Researcher at the Manipal Centre for Philosopy and Humanities, Manipal University) made the translations and was careful enough to point out in his translation what had actually been written.

[135] In her study of visual (and audio-visual) artefacts of Ganapati festival tableaux (mandaps), Raminder Kaur remarks on the collage and reinterpretation of public media imagery relating broadly to politics and religion. Commenting on the level of agency that could be read into these vernacular displays she writes, "I note that discourses evident in many of these sites of popular culture neither follow governmental ideology nor provide a space for outright resistance to state decisions. Rather, they present a space for critique and reflection in culturally inflected and imaginative ways that *draws* upon state/elite and activist discourse but is not hemmed in by them" (Kaur, 2009, p. 152, italics in original). The inflection that Kaur pinpoints here in the reassembly of state-derived media has a correspondence with the inflection of authorship that I attempt to describe through the drawings.

Figure 34

Figure 35

Figure 36

Figure 37

Figures 34-36 show possible source images for the drawing in **Figure 37**. A pupil at Drishya Learning Centre made this drawing during a Moon Vehicle workshop. **Figure 34** is an illustration of a rocket from the book *Chandrayaan-1 India's Giant Leap* by B.R. Guruprasad (2009). **Figure 35** is of a collaged image probably found in a newspaper used by one of the children in the workshop to decorate their portfolio. **Figure 36** is a sticker made to mark the launch of Chandrayaan given to the children on their visit to the ISRO Satellite Centre and again used to decorate a portfolio. (photos: the author) *(Figures 34 and 36 reproduced courtesy of ISRO; Figure 37 reproduced courtesy of Drishya Learning Centre*) authorship within a child's drawing made for a school project, albeit an extra-curricula summer school, can be questioned, but the presence within the drawing of a signature of a person is evident in the mark-making and decision-making made accessible in its articulation. It would be a mistake not to read into the production of drawings, performance and constructions produced, autobiographical strains of interpretation. In the performances developed by the children after their visit this autobiographical link was more evident with stories of family arguments transferred onto the interactions of planets and spacecraft. In the drawings, the hint is subtler yet within the depictions of repeated facts and copies of representations there is a grittiness: A remix, a drift, an interference, a recontextualisation. The drawing marks the locus of an interruption and an interpretation, a particularity of person, place and time: A delicate abrasion that indicates the intimate space of a person.[136]

Summary

The artistic approach, used in the Moon Vehicle project as a method of enquiry produced not only visual artefacts but operated through a multivalent visuality. The process of seeing Chandrayaan consisted of such things as encounters with personnel, ISRO sites and glimpses of instrumentation and data which brought a sense of closeness to the actual journey of the spacecraft and to its mental spaces of scientific analytics, technical complexity, local and global politics. Views of actual places and things, insights into what others saw, the perspectives of mission teams and local children were part of a visuality made more visible and accessible through the artistic intervention. This produced a view of the technology as social interactions, as imagined landscapes and as landscapes mediated by architectures of space technology. The closeness of Moon Vehicle to the producers of Chandrayaan afforded a movement through the

[136] I have kept details of the children's workshop to a minimum partly because the communities the children are from are understandably sensitive to reports made about them by researchers from outside. Mostly though I would like the experiences to remain with the children, rather than making them available as information for analysis. After writing an article about the workshop (Griffin, 2012) I realised also that I could draw insights from the workshop without always presenting the detail. In that article the same drawings are used and I have included the children's names in the image captions. In this thesis though I have not named facilitators, students or scientists throughout and have decided to leave the drawings anonymous to be consistent.

spaces of the spacecraft that made its social and immaterial distribution tangible and available to be directly experienced. The study revealed a realm of experience of the spacecraft accessible at the proximal zone of its production and made available through encounters that opened paths to aesthetic readings, visual and performative interpretations. The artistic intervention enabled spaces of affect such as curiosity, attachment and shared endeavour to become more visible.

The access to affective spaces made available through the workshops and encounters of the Moon Vehicle project may only have been available to its participants or only been produced in that context. The participants may to an extent have invented them or they may have pre-existed in other modalities. What has been argued is that the artist-led activities drew attention to the heterogeneity and distinctiveness of first-person viewpoints. Further, the staging of the project was a demonstration of new kinds of agencies, a demonstration of uses of space technologies for purposes not envisioned in space agency rationales, for types of educational enquiry, creativity and reflection and for critical public forums. The next section considers the project again from the perspective of what motivated its inception. These motivations are related to theoretical perspectives on cultural technologies in order to draw out patterns that at the time of the engagement were only sensed as anxieties. This next section adds a layer of understanding to the commentary on the viewpoint of the drawing, which is revisited at the end of the chapter.

Part Two: Motivations and tactics

Theoretical perspectives: Cultural technologies

The motivations behind the Moon Vehicle project will be considered next through the lens of theoretical perspectives on cultural technologies to understand empirical evidence from the project in terms of patterns recognised elsewhere in the cultural effects of technologies. The idea of cultural technologies is explored in the work of the Canadian media theorist Jody Berland in her book *North of Empire: Essays on the cultural technologies of space* (2009) in which she makes specific connections to space technologies and their effects on perceptions of other kinds of space, such as national landscapes. Berland began in the mid-nineties to reflectively consider satellites and especially satellite imagery as part of the emerging discourse of cybernetics, technology and culture. Her essay 'Mapping Space: Imaging technologies and the planetary body' (1996) considers the cultural assumptions present in the passage of satellite imagery into weather reports at the border of Canada and the United States. In this essay, by showing that weather, as televised in the United States, finishes at the border with Canada, but that weather as televised in Canada, continues across the border, she extrapolates some mechanisms by which empire, in this case the United States, reinforces its governance, "In other words these are maps of technoterritory as much as they are maps of geophysical terrain" (p. 125). In her later book that develops some of these ideas further, she uses the term cultural technologies and links this to Foucault's concept of "governmentality" (Berland, 2009, p. 11; Foucault, 1978). Berland draws attention to the use of satellite imagery in weather reports and the hidden operations of governmental control. Foucault's concept of governmentality – the art of tactically controlling populations without their awareness – delineates mechanisms by which state control is obscured:

> ...it is the population itself on which government will act either directly through large-scale campaigns, or indirectly through techniques that will make possible, without the full awareness of the people, the stimulation of birth rates, the directing of the flow of population in to certain regions or activities, etc. [...] the population is the subject of needs, of aspirations, but it is also the object in the hands of the government, aware, *vis-à-vis* the government, of what it wants, but ignorant of what is being done to it. (Burchill et al., 1978, 1991, p. 100)

Berland echoes this concern for the insidious operations of governance and empire when she writes, "Part of the constitution of mediated or teletopographic geopolitical space is the growing distance between those who cannot discern these connections and those for whom such connections are fundamental" (2009, pp. 6-7). She applies the concept of governmentality to ubiquitous forms of mediating technologies drawing attention to the difficulty in discerning the embedded assumptions present in technologies. As such her approach has much in common with the research of technology historian and theorist Rosalind Williams and media technology theorist Lisa Parks. There is a strong link also with the work of the peace studies scholar Johan Galtung who saw in such hidden agendas a "structural violence" (1969) at a cognitive level imposed surreptitiously on users. Galtung was particularly concerned with the effects of new large-scale development projects in the 1960s and 70s that were carried out with beneficial intentions such as eliminating poverty. His work will be considered more closely in Chapter 5 in relation to a large-scale development project in India that used space technology. The work of these theorists helps to clarify a space of agency, which in the case of certain large-scale technologies is often severely limited, where cultural inflection and the adaptation of technology can take place. Their work helps to explain what a cultural technology could be and how this category can be thought of as a dimension that may only appear sometimes and to varying extents but is a space in which cultural agency of different kinds can take effect.

Rosalind Williams in her essay 'Cultural Origins and Environmental Implications of Large Technological Systems' (1993) considers how visionary thinking originating in the Enlightenment era has crystallised into technological systems. There is pessimism in her writing because the originating Enlightenment visions that saw large-scale systems as beneficial for society brought also a loss of agency for the populations they were intended to benefit. She traces a diminishing of care for the environment within the same origins that produced the infrastructures of capital. What she concludes is that the only opposition to the environmental degradation she links to large-scale technological systems is to be found via a creative or phenomenological route. Williams notices that walking through spaces or writing about moving through spaces is a way of understanding places that are dislocated by infrastructural architectures that are too large to see or experience as a whole. However, when walking, "knowledge is created from the active involvement of the entire body. What looks like a grid to the *philosophe* loftily surveying humanity as a whole, is experienced by the individual on the ground as a pathway" (Williams, 1993, p. 399). Her argument is pertinent to space technologies which produce dislocated architectures, only ever partially glimpsed and more pertinent still to the drawing, performing, site visits and other artistic approaches used in the Moon Vehicle project, which can be related to the notion of walking as a kind of "cognitive map" (p. 400) suggested by Williams. The motivations of the Moon Vehicle project can be sensed to lie within a similar malaise produced by large systems that almost inevitably force the expression of a more intimate and human scale of agency and participation.

Echoing these concerns, Lisa Parks' article 'Technostruggles and the Satellite Dish: A populist approach to infrastructure' (2012) considers the accessibility of satellite networks at a populist level via the domestic satellite dish. She writes, "As I try to demonstrate, this seemingly most banal of objects is tethered to the most serious kind of social and political struggles" (Parks, 2012, p. 65). In her essay it is the satellite dish, bought at a shop and mounted on the side of a house which is the only indicator of the larger system and also the only point at which users of the system can have any control or agency. She notices how satellite dishes become decorated objects (2012, p. 78) and how the dish is used both as a status symbol as well as interpreted as a sign of bad taste. The presence of concentrations of satellite dishes in urban areas has been used to make politically demeaning remarks about immigration (Parks, 2012, p. 75). Dishes are technologies imbued with cultural meanings by owners and onlookers alike. Populist meanings emerge beyond and in spite of the intentions of the producers of the dishes and satellite network. Parks, like Williams, concludes that creativity may be the only means to interact with large-scale and otherwise ungraspable technology that presents delimited spaces for control or agency. Creative control may be exercised where a populace, in their interactions with large-scale and ungraspable technological infrastructures, detects delimiting spaces of agency. What Parks also notices is a particular value in actions that take place at the periphery:

> What the preceding examples suggest, is that infrastructures are not uniform throughout and may be differentiated or reinvented at their edges or fringes, at the sites where people figure out how to make them part of their everyday lives. People make, decorate, collect or repurpose satellite dishes for a variety of reasons. These creative practices may flourish in proportion to the level of detachment and alienation that most people feel when faced with satellite television's technicalities. (Parks, 2012, p. 81)

Something happens, she notices, at the periphery that does not take place at a closer range. She calls this a "phenomenology of infrastructure" (2012, p. 67) and her phrase gives place to responses that do not depend on the technical. The position of alienation and disaffection corresponds here with creative intervention. This aligns with the creative use of Chandrayaan presented in this chapter made by groups in many ways detached or alienated from the spacecraft's production. The work of Parks and Williams suggests that creative engagement is indicative of a delimited scope for participation, but has potential to be more.

The present study restores evidence of the awareness of populations of hidden agendas and asymmetries crystallized within certain technological infrastructures, demonstrating more substantially how spaces of agency can be created. The methods of artistic practice, especially the foregrounding of viewpoint and the experiences of seeing that occur during fieldwork, it is argued, make visible the tactics of governmentality present in large-scale systems. This complication of forces that are hidden but nonetheless felt to be present is a key part of the feeling of alienation that large-scale technologies such as satellite networks can produce. Berland uncovers a seam of surreptitious effects of satellite imaging technologies and other technologies that reinforce insidious notions of territory and empire in subliminal ways. In turning now to the motivations behind the seeing of Chandrayaan by the Moon Vehicle project, the presence of an awareness of the tactics of governmentality (in the surreptitious alignment of values of the state with the positivist technocracy of the space programme) is key to understanding those motivations. Berland's use of the term cultural technologies has great breadth (2009, p. 12) that includes "the fissures and spaces in which oppositions or alternatives are inspired and imagined". Taking these fissures and spaces as a central concern, here it is argued that it was precisely the awareness of governmental tactics at work within the production of space technologies that motivated a response.

Tactical responses

At the beginning of the Moon Vehicle project, Geetha Narayanan the Founder-Director of the art and design school gave her perspective on the problem to which the Moon Vehicle project was initiated as a solution. This testimony provides some access to a set of problems discerned at the point of the launch of Chandrayaan. Narayanan spoke of the artist-led project firstly as pioneering in India. She said that while artist-led interventions into scientific and other settings had been going on in other parts of the world,[137] in India the idea of integrating artistic approaches with those of a space agency were relatively new.[138] The question of artists and designers collaborating with ISRO was it seemed unthinkable [139] and had been rejected by the ISRO official, the former Chairman U.R.Rao.[140] The rejection was frustrating and seemed to indicate the polarity between the communities, ISRO involved in a technical and scientific endeavour that demanded focus and seclusion and inevitably produced a hegemony in which the extreme focus and expertise required in ISRO segregated the organisation from other communities and in an extremely polarised way from the artistic community. Narayanan was concerned though with this inability to collaborate because of the remit that ISRO had set itself to act on behalf of society and to be as she put it "people-friendly" saying, "they do have a Development, Education, Communication wing in Ahmedabad, they have made a resolution that they'll be socially minded and responsible and look at the development, but none of that has actually panned out in people-friendly programmes". ISRO from her perspective was failing in its societal remit. Moon Vehicle, as a socially engaged project focusing on ISRO's mission to the Moon, in some ways then was initiated to resolve this. But what can be insinuated as the real purpose was not so much to supply a people-friendly face to ISRO's mission, almost on behalf of ISRO, as to demonstrate to ISRO its failure. More than this, to demonstrate to ISRO that its failure was connected to its rejection of what it was that the arts could offer. A motivation behind the Moon Vehicle project lay in the wish to demonstrate that by paying attention to the processes of engagement adopted in arts practices the nature of this failure and its solution

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[137] For example Artists in Labs in Zurich, the work of The Arts Catalyst in London, the work of SymbioticA in Perth, Australia.

[138] Narayanan had already begun to support long-term artist residencies, such as the artist residency of Yashas Shetty at the National Biological Institute in Bengaluru and Shabnam Virmani's residency exploring the spiritual and musical diaspora of the spiritual leader Kabir. What was unique about these residencies was the long-term commitment she gave to artists and their projects and the generative work of the residencies in that the research activities fed into the curriculum and were shared throughout the college community informing learning and identifying new directions that helped to build a challenging design curriculum.

[139] Although, as will be described in Chapter 5, a collaboration did occur between ISRO and the National Institute of Design in Ahemdabad between 1975 and 1978 in relation to the Kheda TV project and the development of Satellite Instructional Television Experiment.

[140] This rejection has been anecdotally described to me. The organising committee of the Bengaluru Space and Culture Symposium met with U.R.Rao at the end of the symposium to discuss the possibility of future collaboration. Rao could see no reason for this and suggested that they come back when ISRO needed spacesuits designing.

could become apparent. Science and technology in this particularly extreme case of interplanetary travel needed the help of the arts and humanities or it could never fulfill its aspiration to serve humanity or society. This core belief underlay the approach on the space agency made by persons from the arts and humanities.[141]

But what could the arts offer and what else lay behind the offer to collaborate? At this moment at the inception of the Moon Vehicle project the way the problem was articulated from Narayanan's perspective, was marked by a sense of frustration at being prevented from providing a solution for ISRO's failure to be genuinely societal, frustration at being excluded and also a general anxiety towards the nature of the space programme. The launch did not present a clearly defined problem, but rather a sense of an aggravation of existing problems, themselves not clearly articulated. Being excluded from collaborating with ISRO was an issue on the one hand of institutional recognition: The integration of ISRO with the government and state planning contrasted with the art and design school's independent status as a private college, a status which sometimes caused friction with the state education system. The exclusion was not only institutional but also disciplinary. The closeness of the science and technology institute to government and the distance from state policy alignment of the creative arts institution also indicated the exclusion of certain ways of thinking at state level, reflected inevitably in the design of the space mission. The bias was not only reflected in the space programme but in other state planned enterprises.

This exclusion of the art and design college mattered for a reason that seemed unrelated to spacefaring but was actually a fundamental link between the space technology institution of ISRO and the creative arts institution Srishti. Both were involved in education and involved at some level in pursuing educational agendas that were highly conflicting with each other. ISRO had launched EduSat in 2004 as a satellite dedicated to education. However, the satellite was

[141] This group from the arts, design and humanities communities also included representation from the scientific community. Roger Malina who was part of the committee that suggested the Moon Vehicle project was also a space scientist as well as editor of the arts and science *Leonardo* journal. He was also the director of a science institution in Marseilles where he developed the cross-disciplinary exchange programme IMERA predominantly between scientists. So the idea of crossing disciplines and developing dialogues was not only a concern of the arts and humanities, it has also been a concern across scientific communities.

mostly used to facilitate distance learning such as broadcasting television programmes or university lectures. By so doing ISRO had crystallized into the satellite infrastructure a limiting or at least highly specific educational model.[142] Edusat was intended to provide better education to under resourced schools in villages and as such had admirable objectives, but at the same time it undermined local expertise and the value of experiential learning (Sengupta et al., 2005). Furthermore, the educational ideology it seemed most able to promote derived from the model of engineering training, a model most familiar to the ISRO directors of the project such as U. R. Rao (Rao, 2006; 2007).

Narayanan spoke not directly to these developments, but to an issue that touched on a hugely contentious though not overtly evident impact of the spacefaring industry by saying, of the education activities of ISRO that there was "nothing critical, nothing that is Paolo Freirian, pedagogically transformatory, nothing that is experiential". The contention that she alludes to here is in part connected to the way that ISRO favoured a version of education associated with training and with imparting information, rather than the problem-posing approach to education espoused most notably by the educational activist and philosopher Paolo Freire (1972; 1987). This training model of education has much deeper roots within ISRO than the relatively recent Edusat satellite.

The limiting educational proposition can be traced to the vision of Vikram Sarabhai. In Amrita Shah's biography of Sarabhai she provides commentary by his contemporaries, Abu Abraham and Raj Thapar, who question the ability of space technologies to provide empowering education. They criticise the disempowering and controlling effects of space systems, which were nonetheless allowed to pass as societal benefits. The political cartoonist Abu Abraham here astutely comments on the problems of promoting information distribution rather than literacy, "Literacy gives people choice. If you educate people entirely on information they are at the mercy of the government which holds power over the medium" (Shah, 2007, p. 185). In a

[142] A report on the EduSat pilot scheme conducted at engineering colleges (Sengupta et al., 2005) is highly critical of some of the technical failures of the pilot, but more so of the educational bias towards an engineering training model that the technological apparatus supported. Some of these criticisms have reached media attention but have been largely unrecognised. The report is available for instance only in the library of NIAS, Bengaluru.

sense ISRO had created a powerful model of an ideology of education through the hardware of its satellite system but it was one with severe limitations. It appeared to close down choices. The problem that seemed to lie within the production of space technology was the production of ways of thinking, the immaterial cognitive structuring that Galtung cautioned was embedded within material technologies (Galtung, 1969). It can be inferred that the powerful crystallisation of delimiting ideologies into the hardware of space technologies was a cause for anxiety at the time of Chandrayaan's launch and from the perspective of the arts community needed to be challenged. A challenge was needed because a large part of what was being delimited via the space technology infrastructures was liberal, creative and experiential learning as accessed through and exemplified by artistic approaches. The Chandrayaan spacecraft's many mixed motives and messages exacerbated an anxiety over a critical debate about the relation of the space programme to citizens which had never been adequately brought out into the open and critically assessed.

It could be said that Chandrayaan as a cultural technology had drawn attention to a problem in the regulation of spaces other than outer space and specifically to a distancing between those regulating and those being regulated. The problem can also be accessed through Foucault's insight into the nature of governmentality and how regulation of populations is put in place almost unnoticeably, using subtle tactics rather than democratic procedure, "the instruments of government, instead of being laws, now come to be a range of multiform tactics" (Foucault, 1991, p. 95). The tactics of governmentality are ideally invisible to the populations on which they are worked. However populations are not ignorant of such tactics, on the contrary, the tactics of governmentality are often palpably felt. The anxiety present in Narayanan's explanation of the issues motivating the inception of the Moon Vehicle project are indicative of a concern for and curiosity to uncover the tactics by which one is regulated and to which one has limited access. Moon Vehicle can be put in place then as not only a cultural but a critical response using a comparable set of equally tactical methods, mimicking processes of governmentality and mimicking also the kinds of dual-use or poly-use of space technology that has been such a pervasive feature of the political agendas of spacefaring. Hidden within the activities of the Moon Vehicle project were mechanisms to achieve recognition, change, power and inclusion on other registers – such as the acknowledgement of creative, experiential and other heterogeneous styles of learning.

The solution to this perceived problem or set of problems – a solution in the form of an artist-led project – has to be considered though as an approximate solution. The symposium on Space and Culture, the appointment of an artist in residence, the events and workshops of the Moon Vehicle project and the work with children, scientists and others is best understood as an approximate solution to an ill-defined problem, or at least a problem that was possible to discern but difficult to define. In essence, the Moon Vehicle project addressed the problem in a way that exposed it most clearly by positioning, at close quarters to the space agency the image, or demonstration, of what it was that ISRO lacked. The juxtaposition or collage of one with the other produced a figuration or a flickering between the possibilities offered by each.

The viewpoint of a drawing (revisited)

The artistic approach invests in the artist's own viewpoint and experience, synthesised through creative acts of making, performing, drawing and other ways thinking through materials. A drawing can be understood as something that makes a viewpoint visible. The viewpoint of the drawing articulates a seam of criticality that brings attention to qualities of the human often missed in the purview of spacefaring and sometimes also in other kinds of large-scale systems. It calls attention to a quality of choice that is an easily missed component of the affective space of space technologies. The sensibilities and practices of the artistic approach help to make this missed component more visible. Narayanan's reference to a Freirian approach reinforces the sense the missed component relates to the qualities available from first-person viewpoints. Paolo Freire's philosophical and activity-based solution to the problem of oppression amongst populations in Brazil was to use literacy as a way of reading the word and the world and also of writing the word and the world (Freire and Macedo, 1987).[143] Freire's approach to adult literacy was to offer a means to empower oppressed populations and resist top-down control. Writing the world meant allowing an individual to discern the politics influencing their own life and crucially to use the act of writing words to grasp the mechanisms influencing or controlling their own freedom. In a similar way the artistic approach allows for drawing and creativity to be practices that articulate the perspective, location, consciousness and choices of the person making, creating or drawing. The artistic approach invests in the perspective of the first-person, of "I", as the primary experience for making sense of the world and Freire's methods help to illuminate the fundamental place in a politics of resistance of the strategies of reading and writing, and by extension, of drawing. Drawing and writing are not only means of seeing, understanding and grasping the world from the first-person perspective, they are activities in the world that demonstrate or perform that first-person position: Drawing is both inscription and performance, signature and hand.

It is the wish to re-establish the primacy of this perspective that appears to be an overarching characteristic of the Moon Vehicle project and is perhaps the key feature of the adjustment needed to the societal remit of the space agency. It is an adjustment that could apply elsewhere to similar kinds of large-scale problems. Freire's focus through literacy on experiential learning has for instance been highly influential in the field of education. In the field of economics Amartya Sen has introduced a dimension of accountability for the first-person perspective into the measurement of wealth. His adjustment of economic measures shifts the somewhat dehumanising accounts of populations as units of production, generally used in economic analysis, to include a slightly expanded recognition of persons with agency and choice. Sen

[143] Henri Giroux writes in the introduction to *Literacy: Reading the Word and the World* (1987) "Central to Freire's approach to literacy is a dialectical relationship between human beings and the world, on the one hand, and language and transformative agency, on the other. Within this perspective, literacy is not approached as merely a technical skill to be acquired, but as a necessary foundation for cultural action for freedom, a central aspect of what it means to be a self and socially constructed agent." (p. 7). A person has awareness of the historical processes that have constructed their experiences. Literacy then becomes a means by which to reflect on one's own experience and then have the means to exercise choice, Giroux continues, "To be able to name one's experience is part of what it meant to "read" the world and to begin to understand the limits *and* possibilities that make up the larger society". Bringing attention in this thesis to the activity of drawing and thereby the first-person viewpoint, shows how in a comparable way the activity of drawing, like literacy, acts as a pivot for reflection, for reading the world as a first stage for rewriting the world.

writes of, "substantive freedoms - the capabilities - to choose a life one has reason to value" (Sen, 1999, p. 74). His placing of value is a very slight adjustment to the economic analysis of personhood and yet it inverts and makes transparent how the top-down approaches generally used in economic analysis make misleading assumptions about their subject. The problem in economics that he addresses is that of turning people into economic units and obviating the differences in how people feel about their lives and what it is that different people require in order to be happy. It can be argued that Sen replaces a missed component in the economic analysis of poverty by impressing the existence of the first-person viewpoint, which in his analysis is choice, into the large-scale systems of economic analysis. By recognising this viewpoint, agency and choice become valued and are rendered visible and accountable. Such large-scale systems of economics that Sen addresses falter when they do not take into account this viewpoint which adjusts to particular person's circumstances and values, and without which can lead to skewed analyses of social need.

To draw this claim back more tangibly to evidence and the first-person experiences that are the focus of this study. Some of the artwork produced provided clues to the nature of this viewpoint that enfolded the experience of seeing and being seen. That experience and its demonstration in the act of drawing also recalls a claim made in Chapter 2 that experience holds a ambivalent relation to authorship and ownership of that experience. Drawing in a sense provides an answer to Sarukkai's question of whether an individual can be the author of her own experience. Drawing demonstrates authorship of ones own experience. It establishes one's own perspective as tangible. Artistic expression is culturally bound to the expression of authorship – works of art are typically signed. The drawn mark is like a signature that encodes the identity of the artist into the mark. There is empathy between the artistic process that inevitably foregrounds seeing (and not seeing) and processes of resistance that require demonstrations of agencies. Artistic processes show what is otherwise without image.

This insight leads into the next chapter. The question of who is in control of space technology and for whom space technology is made casts a shadow on the assertions of agency that have been made in this chapter. Creative intervention may constitute a use of space technology or a degree of merging, but those involved in the workshops and activities described remain subalterns, that is without any substantial determining power to influence technological form or purpose. In the next chapter the position of the subaltern is considered in relation to other space technology contexts and in relation to a structuring effect of the visible and invisible at a metaphorical level. This moves the argument of the thesis on to reconsider in the final chapter the technography of the spacecraft in relation to a subaltern aesthetic that emerges from this analysis.

Chapter 5

Optics of a subaltern experience

The term 'optics' has connotations with a physics of light experiment. In such an experiment there might be a source of light, an object onto which the light is cast and some kind of interruption to the flow of light – a medium such as a prism or obstruction such as slits in a card. The term optics is used in this chapter to loosely foreground the ways that seeing and visuality imply an arrangement of players or distributed apparatus in metaphorical, imaginary and physical spaces.

The previous chapter identified a missed component in accounts made of who it is that spacefaring is for by demonstrating a heterogeneity of ways of responding to, using or interpreting the spacecraft, not well accounted for in the rationales of the space agency. The artist-led project helped to show that a sense of being alienated from the core values of the Moon mission was not just a characteristic found amongst those outside the space agency, but could also be felt by those within. Such feelings of alienation found more obviously away from the space agency and less obviously within the space agency could be given the term subalternism. This term implies a position of lesser agency or a sense that one's own viewpoint is not well accounted for.

In this chapter some insights from a relatively small and focused group of history scholars called the Subaltern Studies Group are used to structure the claim of this thesis and to overlay its more contemporary observations onto an established discourse of subalternism. By making this move a common thread between the use of the metaphor of optics by some scholars of the

Subaltern Studies Group and the foregrounding of seeing, viewpoint and experience in this thesis are aligned. This alignment of the optical figure of speech and the research method using visual practice to interpret and theorise some overlooked aspects of the affective space of space technologies aims to substantiate the value of bringing an artistic approach to space technology. Subaltern scholars for instance note "optical errors" where viewpoints are unaccounted. The comparison in many ways provides a reflective staging of the argument presented in the thesis.

One of the ways the insights of subaltern scholars helps substantiate the work of the thesis is that it provides a method of looking at historical documents with alertness to fragile evidence of subaltern agency, viewpoint, experience and voice. The method of accessing subaltern experience through documents allows a formational episode in the establishment of the societal space programme in India to be re-examined. The lens of subaltern scholarship and the lens of the artist-led project presented in the previous three chapters helps open up some core aspects of the relation of space technology to social domains that in these formational years were somewhat overlooked. Two things are proposed – first that the complications of purpose and use within the formational projects of the societal space programme were overshadowed by the imagined success of the impressive space borne technology. Secondly, that these complications remained and resurfaced in the artist-led project presented in the previous chapter.

In the first part of the chapter subaltern studies is introduced. This is followed by a short analysis of the Satellite Instructional Television Experiment that took place in 1975/6 across 2400 villages in India, through which the India space agency establishment an innovative societal application of space technology that was unique in the world. The disempowering aspects of the subaltern experience of space technology are then reconsidered in the light of a theoretical model proposed by the historian Dipesh Chakrabarty. This model proposes that an entanglement of viewpoints actively shape both histories and the present. It is a model that reinstates the agency of subalternism, removing the vulnerability and assumed passivity of such positions. For the thesis this further substantiates creative, critical intervention as a robust assertion with a distinctive place in the collective endeavour of spaceflight. There is in the artistic approach that combines creative practice with criticality the robust assertion of qualities of the experiential, first-person viewpoint through which agencies available from subaltern positions can be expanded.

What is subaltern discourse?

A collective of historians called the Subaltern Studies Group, published their first volume of essays in 1982.[144] Their revisionist historiographies were written as a reaction to what they saw as the colonialist and elitist writing of Indian history, which failed to account for the largest group of makers of that history – the subaltern classes. (Said, 1988). The term subaltern is used to mean economically dispossessed or those in an asymmetric relation to power and in general the opposite of elite or dominant positions. It is a term borrowed from Antonio Gramsci the Marxist thinker, writer and activist, who coined the notion of "subaltern classes" for his accounts of social categorisation written during the fascist uprising in Italy and moves by the party leader Mussolini to create a one-party system. Gramsci was imprisoned for his political views which were perceived as a threat to the dictatorship. His use of the term subaltern indicated a position within social relations lacking determining power. He took the term from the 'subaltern officer', a junior officer in the Napoleonic army who would pass orders from the higher ranks to the foot soldiers, an essential procedure in the working of the whole army, but an invisible, un-heroic one. Of the role of the subaltern in societal relations Gramsci wrote:

> They have no autonomous initiative in elaborating plans for construction. Their job is to articulate the relationship between the entrepreneur and the instrumental mass and to carry out the immediate execution of the production plan decided by the industrial general staff. (Forgacs, 2000, p. 308).

The subaltern articulated a relationship in which she always stood in relation to other more determining forces. In Gramsci's terms the subaltern did not hold a fixed or named position,

[144] Dipesh Chakrabarty writing of the group (2000b) gives the following as members of the group at that time: Shahid Amin, David Arnold, Gautam Bhadra, Dipesh Vhakrabarty, Partha Chatterjee, David Hardiman, Sudipta Kaviraj, Shail Mayaram, Gyan Pandey, M.S.S. Pandian, Gyan Prakash, Susie Tharu, Gayatri Chakravorty Spivak, and Ajay Skara, with Sumit Sarkar a member during the 1980's (Chakrabarty, 2000b, footnote 1).

subaltern was a relative term and denoted a relative space in which a subject was denied access to or inhibited from a more determining relational position.

The meaning and context of the subaltern in the work of the Subaltern Studies Group had a slightly different function in this primarily historiographic project than in the political writings of Gramsci.[145] Indian colonial histories up till this point had tended to focus on the conflict between British and Indian, and on the role of the Nationalist movement, led by such well-known figures as Gandhi and Nehru, as the determining force behind all acts of insurgency against the British Raj. Ranajit Guha was the editor of the series of volumes titled *Subaltern Studies*, gathering together the work of scholars and creating a sense of cohesion amidst differing views of subalternism (Prakash, 1994, p. 1478). Guha stated that this tendency had resulted in an inadequate account of the many types of resistances and their many types of causes and rationales running with or counter to the Nationalist movement. Further, that the leaders of the Nationalist movement, such as Gandhi, Nehru and Jinnah, even though marking themselves as subalterns involved in non-violent insurrection against a dominating foreign power, still represented another kind of elite that obscured the motivations and methods of other insurrectionists (Said, 1988, p. vi). The re-insertion of the heterogeneous actions of subalterns (through the writings of the Subaltern Studies Group) aimed to dislodge the dominance of existing narrow historical interpretations, and, as Edward Said points out in his foreword to *Selected Subaltern Studies* (1988) allowed subaltern struggles a continued medium of resistance through this new set of texts.

The purpose of the Subaltern Studies Group was to find the voices of these missing actors in official documentation such as factory inspector's reports or government communications. For these social historians, their subjects left no personal records, but were largely spoken for in such documents. In his social and economic theories Karl Marx had been able to use similar kinds of documents to provide historical accounts of the English working class in order to build his theory of capital (1867). The Subaltern Studies Group followed Marx in some ways in this

[145] Gramsci was concerned with the political realities in Italy of the dictatorship of Mussolini, which he was living through. He looked at social categorisations as a means to think through the possibilities of social revolution.

methodology, and were politically sympathetic, but were interested in finding the authentic voice and situations of the subaltern, so their analyses went beyond the political and economic focus used by Marx to find the cultural authenticity of their historical subject. In Guha's defining essay, 'The Prose of Counter-Insurgency' (1988), Guha clarifies the group's methodology of using official documentation written by clerks as sources of information, which gave a sense of "immediacy" to events because they "were written either concurrently with or soon after the event" by "participants" who were "a contemporary involved in the event either in action or indirectly as an onlooker". To illustrate this he provides at the beginning of this essay copies of two letters by clerks written in response to uprisings. One written in 1831 begins "Authentic information having reached Government that a body of Fanatic Insurgents are now committing the most daring and wanton atrocities on the Inhabitants of the Country..." (Guha, 1988, p. 48) illustrates the kinds of documents connecting to real situations that were drawn on. Such documents gave evidence of the unvoiced presence and activities of subaltern insurgents or workers and also to the voices of the clerks themselves. In this detail, the clerk as an intermediary carries an uncanny resemblance to the original subaltern officer. In a way, the anonymous clerks, both British and Indian, like the junior subaltern officers of the Napoleonic army, have an invisible presence within the Subaltern histories, marking a passage of communication, event and experience. While the term 'subaltern' in these writings most often meant the peasants or factory workers whose histories were being excavated, the prose of counter-insurgency – the writing by clerks on the opposite side of the insurgents – was in itself the equivalent work of the junior 'subaltern officer' of the Napoleonic army from whose mediating and comparatively un-heroic work the term originated. Ultimately the term 'subaltern' is then a relational space rather than fixed by occupation or economic status and the excavation of voice in the Subaltern Studies project has a reflexive poetics.

Outlining some core problems in the treatment of subalterns in historical accounts, Guha explains in 'The Prose of Counter-Insurgency' that the problem of much historiography has been the negative assumptions made about the causes of subaltern insurgency, which always assumed a lack of complex reasoning characterised as a wildness:

> ... triggering off rebellion as a sort of reflex action, that is, as an instinctive and almost mindless response to physical suffering of one kind or another (e.g. hunger, torture, forced labour, etc.) or as a passive reaction to some initiative of his superordinate enemy (Guha, 1988, p. 47).

The work of the Subaltern Studies historians was, through painstaking research, to find the authentic, internal criteria for actions and not to create historical narratives based on suppositions drawn from external criteria.

Referring to the 'missing' subaltern voice Guha asks, "How did historiography come to acquire this blind spot and never find a cure?" (Guha, 1988, p. 47). To address the blind spot Guha suggests, "For an answer one could start by having a close look at its constituting elements and examine those cuts, seams and stitches -- those cobbling marks -- which tell us about the material it is made of and the manner of its absorption into the fabric of writing." (Guha, 1988, p. 47) Guha's methodology and that of others in the Group is extremely rigourous. The essays detail their sources in ways that make reading demanding, they are not easy narratives because they have to nail the specifics of their revisionist interpretations against the grain of the canon. Yet the Subaltern historiographies contain the kind of poetic relation to their material that Guha alludes to here when he writes of the "cobbling marks" and their "absorption into the fabric of writing". Essays such as Dipesh Chakrabarty's 'Conditions for Knowledge of Working-Class Conditions' are long and detailed, in order to ultimately reach a position close to a phenomenological connection with their subject.[146] A characteristic of this poetical and rigourous method is the resistance to creating seamless narratives from the documentary evidence available, instead leaving the "gaps and silences" to speak for themselves, because as Chakrabarty writes, "the gaps have a history too" (Chakrabarty, 1983, p. 230). Chakrabarty's essay 'Conditions for Knowledge of Working Class Conditions: Employers, Government and the jute workers of Calcutta, 1890-1940' admits, "It is thus a history both of our knowledge and of our ignorance" (Chakrabarty, 1983, p. 185). Official documents, he finds are not straight forward they can contain evidence of resistances. Their silences he finds indicate systems of

[146] Chakrabarty in this essay shows that the real authority of the factory was held in a system of pre-industrial social relations, unaccounted for by the notion of 'working-class' as used by Marx which was based on an English working class. In this essay Chakrabarty begins to draw out incommensurability of European theory with the Indian context which he later expands in his book *Provincialising Europe* (2000a).

organisation for which no documentation could provide an account.[147] For instance, in his evidence Chakrabarty cites reports by factory officials that gloss over the unhealthy conditions of work, even though factory legislation aimed at improvements in order to improve efficiency,[148] he writes, "At heart, this was the employer's argument" (1983, p. 194). Chakrabarty refers to these discrepancies and disjunctures as "the 'optical errors' of that vision" (1983, p. 195), meaning the blind spot of the combined state-employer's vision, in other words officials saw only what was needed.

Subalternism in space agencies

Such "optical errors" are relevant also to the problem of discerning the mechanisms that operate between space technologies and their affect. These blind spots and omissions also speak, or at least they make appearances, and can be marked as space holders in the absence of actual voice as spaces that require inference. What Guha identifies as a historical "blind spot", could equally be transferred to the inconsistencies that have been found within the certainties applied to space technologies and spacefaring. There are a number of respects in which the methodology of the subaltern scholars corresponds with the approach of revisionist social scientist Diane Vaughan (1997) who painstakingly reassembled the circumstances leading up to the explosion of the Challenger space shuttle in 1986 in order to add detail to the interpretation by the official investigation. In her argument the official investigation did not sufficiently take account of the viewpoint from which engineers and managers acted. In her reconstruction of events, Vaughan emphasised the necessity of staging an interpretation from the 'native viewpoint', that is, from an understanding of the working culture in which certain actions took place. Her study revealed how certain actions that looked irrational or negligent from the outside perspective were normal

[147] He reveals how factory life was organised through the independent authority of the *sardar* sanctioned through social custom, rather than the new capitalist system of production.

[148] For the "official 'mind'" (1983, p. 191) only epidemics were a cause of concern because they meant a smaller workforce. Chakrabarty shows how the employer's concern, or lack thereof, differed substantially from the lived experience of the factory. He finds anther version of factory life hovers between official reports and other sources. For instance he uses a report by a female doctor of the health issues she encountered visiting women on the factory line to point out the bias of employer's accounts (1983, p. 195) of which he writes, "To most of the factory inspectors - contrary to the aims of the factory legislation - the conditions always seemed satisfactory" (1983, p. 191).

and rational within the "frame of reference" of the organisation or community. Vaughan refers continually to the need to understand the decisions of NASA management and engineers from within their "frame of reference", which included a history of acceptable practices going back to the early days of spacefaring. In reference to the teleconferences in which decisions later identified as incriminating were made she writes:

> The teleconference was a microcosm through which we watched these patterns of the past reproduced in a single, dynamic exchange. In a situation of perhaps unparalleled uncertainty for those assembled, all participants' behavior was scripted in advance by the triumvirate of cultural imperatives that shaped their previous choices. The preexisting scientific paradigm and its dominant ideology, the belief in redundancy, formed the all-important frame of reference for the information that was presented. (1997, p. 398).

She provides a guide to understanding the paradigm on which employees of the space agency and its subsidiaries based their judgments. The "belief in redundancy" was key. Redundancy meant that design included secondary systems in case a primary system failed. While not entirely fail-safe, redundancy constituted 'acceptable risk' in the production workplace. Belief in the resilience of technology that was not perfect part of the community make up. Those who had experienced making fine engineering judgments trusted in the system of decision-making adopted because it worked in practice even though it sounded imperfect and risky to those outside the space organisation.

In many ways, Vaughan's ethnographically sourced reconstruction of events is a subaltern history that puts back together the micro-systems of the working conditions at NASA. Her revision of events restores the credibility of the engineers and decision makers by putting back together the frame of reference in which they occurred. Crucially Vaughan makes clear that this frame of reference was not available to the non-native point of view. In her account the term subaltern is not used, and it would seem out of place to use in reference to the apparently privileged work environment of NASA and subsidiary companies, and yet, the spaces available to engineers, managers and others of the workforce are all bound in some way to each others relative positions of responsibility. All have a certain agency and voice, but there are structural limitations to voicing that Vaughan is able to elucidate. There are ways that each of the players, the real people called to testify in the Challenger investigation, are subalterns to some extent within their projects and the overarching and systemically originating systems of their own workplaces. Each plays only a small part in a larger system.

Such revisionist accounts as Vaughan's are a reminder of the missed points of view of the individual employees and the mechanisms by which they share in a collective culture. A reminder too of the consequences of missing such points of view as well as the tenacity needed to reconstruct and access elusive qualities of viewpoint. The revisionist methodology and the restoration of native viewpoint is an important tool for excavating elusive mechanisms present only in the most intimate spaces captured through ethnographic study (Vaughan) or rigorous study of documentation (Subaltern Studies Group). These methods of access it is argued here can be supplemented with the visual attentiveness of the artistic approach.

The visual journey which Vaughan's study takes to workplaces, teleconference rooms, to the historical setting of the early space programme and also to the traumatic last moments of the Challenger itself provide, in her terms, a thick ethnography. But her report also provides a cinematic scoping of the most intimate spaces of the NASA agency workplace. Vaughan provides reports from inside the separate teleconference rooms where the crucial decisions to launch were taken in their various locations across the United States and compares these in situ communications to what was heard via the telecom. In the transferences from in situ communication to telecommunication there is a notable loss of the uncertainty communicated betweeen witnesses present in the same room.

While Vaughan recognises the nuance of the spoken word, her account also produces a visual imaginary although the visual is not specifically used or elaborated on in her account. That this visual imaginary could also become an insightful layer in the account is hinted in an essay by Michael Punt (1995) in which he suggests that had attention been paid to visual evidence during the launch from video cameras placed on the shuttle, a quicker response could have been made. This is developed through a discussion within the essay of a delinking of the visual from current science and technology and a linking of the visual instead to the lesser pursuits of entertainment and education. Within Punt's essay what is indicated is the lack of attention given to highly pervasive forms of visuality within the operation of space agencies that are overlooked. It becomes clear in reading Vaughan's report – although this point is not specifically asserted – that the engineer's gut feeling (1997, pp. 95-141) of an issue with the O-ring joints[149] had a basis in the engineer's own sighting of the corroded joints after tests. Images of the corroded O-rings were not distributed. Only memoranda with linear graphs of temperature data were faxed between the teleconference rooms. Vaughan reproduces these in her book (1997, pp. 293-299) and the paucity of rich information in the faxes is palpable. It is a paucity of the kind of visually rich information that Ferguson in his article 'The Mind's Eye: Nonverbal thought in technology' (1977) called attention to as crucial to the modality of engineering practice.

If missed viewpoints and spaces of agency constitute an 'optical error', this suggests that attentiveness to the visual and its corollary the visual imaginary may help to correct this error. Subalternism is not dependent on the physical arrangement and geographical position of persons so much as how the light is cast, how the lens is used and what is observed and valued. Subalterns can be found both at a distance from the space agency and within its privileged spaces. Experiences and viewpoints can become obviated in the large scale projects of spacefaring which are arguably more attentive to the materiality of technology. The optics of subalternism accompanying the production of space technology can be further excavated through the architectures of viewing evident in documentation of a space technlogy project that took place in India during the 1970s called the Satellite Instructional Television Experiment. The metaphorical optical layering alluded to by subaltern scholars, translates into a more substantial figuration of viewing as television is transmitted through the space satellite system.

[149] The O-ring joints were part of the Solid Rocket Booster (SRB) fuel valve. They were made of a rubber material and sealed a valve. The problem with the O-rings that lead to the explosion of the fuel cylinder on Challenger space shuttle was that the low temperature on the morning of the launch caused the rubber to be too brittle to seal properly and there was a fuel leak that lead to the explosion. Anxieties among engineers and managers during pre-flight conference discussions concerned a lack of data as to how O-rings would work in low temperatures. The physicist Richard Feynman who was part of the original investigation team famously demonstrated the brittleness of a frozen O-ring during the hearing by dropping one into ice water and then breaking it.

The Satellite Instructional Television Experiment – SITE

The Satellite Instructional Television Experiment (SITE) was a one year project that ran from 1 August 1975 to the 31 July 1976 which put satellite televisions into 2400 villages across India. It was an experiment in the building and management of technology for direct broadcast television using the United States ATS-6 satellite and an infrastructure of ground stations, transmitters, antennas, village-based receivers and televisions. In a short film made in 1971 called *Space and India* by Films Division Director Vijay B. Chandra (see Appendix 4) the space programme director Vikram Sarabhai is interviewed explaining the proposed new concept. As he speaks he draws on a blackboard the diagram of the relation of the satellite to the low cost receiver placed in a village and is visibly excited at this technological advancement, saying:

> The biggest breakthrough that is likely to take place is a great economy in the cost of the ground station that you can take it to. A normal Earth ground station [...] costs several crores[150] of rupees, but, with an increase of power on the satellite it will be possible, to directly receive to television sets with small antennas, and this whole installation might cost no more than 2000 rupees. (*Space and India*, 1971)

Stills from this section of the film are shown in Panel 13. The scene in the film is cut next to images of viewers watching television that would have been taken in a district called Kheda where a pilot television project had started in 1967 led by U.R. Rao (who would later become Chairman of ISRO). The Kheda pilot used an antenna located in Ahemdabad, not in space, but was carried out in preparation for full scale satellite broadcasts. It was an ISRO project run by ISRO technicians, engineers and ISRO media producers and it was used as a test bed for the larger scale, UNESCO funded SITE project as a place from which to develop programming, technology and audiences. In the Kheda television project a programme called *Krishi Darshan* (1967) began to be broadcast, which was a farming programme and translates as 'glimpse of farming'. *Darshan* is a commonly used yet potent word that describes seeing a god. The idea of *darshan* has a particular potency within the Hindu faith because when you look the god also sees you. The word is used commonly also to give a sense of a glimpse, but it has more charge

[150] A monetary unit used in India 1 Crore rupee = 10 000 000.

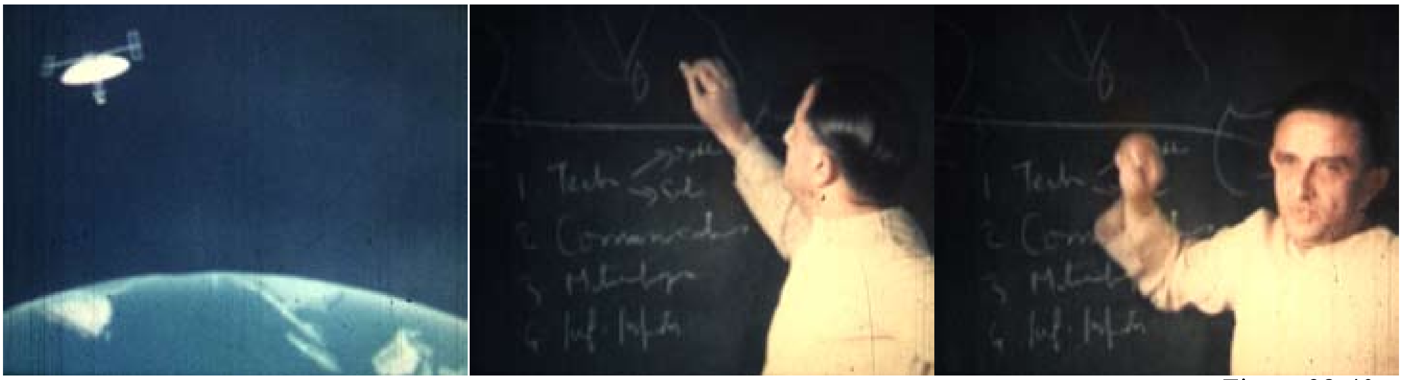

Figure 38-40

Figure 41-44

Figures 38-44 are stills from the film *Space and India* (1971) directed by Vijay B. Chandra and produced by Films Division, Ministry of Information and Broadcasting, Government of India. **Figures 38-40** show Vikram Sarabhai at a blackboard explaining how satellite television broadcast will work using an ATS-6 satellite (shown to the left). **Figures 41-44** show audiences watching the programme *Krishi Darshan,* which began broadcasting in 1969 as part of a pilot project in the district of Kheda. The pilot was for the Satelite Instructional Television Experiment (SITE), a one-year project that took place between 1975-6. (*Images reproduced courtesy of Films Division India*) than the English word 'glimpse' because of this divine association. *Darshan* instills reverence to the act of looking and a sense that what is looked at also gives back something to the viewer.[151]

Image Panel 13 shows stills from the film *Space and India* (1971) in which audiences are shown watching *Krishi Darshan* (see also film transcript in Appendix 4). It became the longest running programme on Indian television and is still being broadcast. However, the image sequences in the film hint at a problem fundamental to television viewing: the lack of participation and agency of viewers. Whereas the space programme leader Sarabhai explains with great excitement the plan as he saw it and emphasises the "confidence" that having such a satellite system will give to the people of India, his enthusiasm and involvement contrasts with the stillness and passivity of the television viewers filmed. The viewers are not only slightly conscious of being filmed, but their stillness contrasts with other shots shown in the rest of the film of men and women farming and otherwise in action.

Kheda TV and SITE were an experiment in creating 'instructional' programming for rural audiences and as an 'experiment' entailed detailed data-gathering. What is of particular fascination about SITE is the intermingling of the social and the technological within a single experiment and vision together with the fact that this ground-breaking social project was led by the space agency ISRO. At the Satellite Applications Centre (SAC) in Ahemdabad anthropologists, media producers and engineers worked together to pioneer a radical application of space technologies for constituencies who seemed profoundly separated from the global

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[151] The idea of *darshan* resonates with the two-way visuality of seeing and being seen which was emphasised in Chapter 4. A number of writers have used the idea of *darshan* analytically, for instance Alfred Gell in *Art and Agency* (1998, pp. 116-120) who explores the intersubjectivity as well as the union of seeing and being seen between god and devotee. Kama MacLean writes of *darshan* at Kumbh Mela festivals and frictions between established customs of looking and seeing and practices of press and tourist photography (2009). Although the concept is apposite to my inquiry in many ways I felt as a non-Hindu that my familiarity with the word was still fairly new and that real understanding of the word's meaning should come from a long-term belief and experience of its properties. Without that experience, the use of the word for analytical purposes may be liable to sap or reduce important transcendental properties and meanings of the word. Christopher Pinney (2004) for instance uses the concept of *darshan* in his book on printed images of gods. In a critique of Pinney's work by Ajay J. Sinha (2007), Sinha criticises Pinney for deriving his understanding of the term mainly from Lawrence Babb's paper 'Glancing: Visual interaction in Hinduism' (1981) and Diane Eck's book *Darsan: Seeing the divine image in India* (1998). Sinha notes in Pinney's analysis a "periodizing" of practices of seeing written with "bracing clarity and polemical sharpness" (p. 196) that suggests the "Indian Hindu scopic regimes" that Pinney attempts to describe are limited by the coherency of the analysis. In Pinney's analytical coherency the modulations in types of Hinduism and types of temporality are smoothed over, the lived experience of *darshan* lost to an extent.

connectivity envisioned from the new vantage point of outer space. The general assumption that this project was a success laid the ground for the identification of the Indian space programme as uniquely societally oriented. In many ways it proved that a connection was possible between the most iconically 'modern' space-located technology and the most iconically 'anti-modern' village dweller of the Indian subcontinent. Ideologically SITE dislodged assumptions about what modernity looked like and where it should emerge. It indicated that assumptions about how space technology could actually benefit humanity had been narrowly conceived. It was a gesture that visibly demonstrated that the presumed ownership of modernity by the so-called 'West' or by so-called 'developed' nations could be 'leapfrogged' such that the current order of leaders and led, of 'developed' and 'developing', could be inverted. If the most stereotypically 'pre-modern' village-dweller of rural India, habitually labeled 'backward' and 'traditional', could leapfrog ahead of the technological curve and be the first in the world to receive satellite television *en masse*, then several imaginaries could be broken at once including the determining imaginaries by which the world was being divided at that time between rich and poor, which locked nations such as India into disadvantageous positions. Much was at stake here if such constructs could be destabilised via the potency of this new shift in the imaginary of spacefaring and who it was for.

Generally the rhetoric used to justify SITE was based on the unquestionable advantages foreseen by planners of the space system in modernising and changing village life. One report states, "Kheda television was thought to be a "lab" close to the scientists for innovation and experimentation in SITE and aimed at affecting changes in the behavioural patterns of the poor"(Agrawal and Malek, 1986, p. 66). This statement indicates how change was envisioned as a one-way process rather than a two-way cultural exchange. This follows the prevailing assumption at the time that being cut off from the new global village was a disadvantage. It is an assumption that is questioned by Ivan Illich in his essay 'The De-linking of Peace and Development' (1980) in which he argues against the grain of the presumptions that being absorbed into the global whole is beneficial. In this essay he argued that the new concept of "world peace" had obviated the option to be peacefully left alone and 'off the grid'.[152] But SITE aimed to put villagers on the grid as part of an innovative and progressive move that was intended to demonstrate a state that cared for its people.

Much documentation exists about SITE because as an experiment the gathering of data and the production of documentation was a major part of the project. Not only were receiving television sets installed in 2400 villages and large chicken wire antenna dishes fabricated for each, but an equivalent number of anthropologists stayed, one in each village, from six months before the television sets were turned on up to the close of the project one year on. The anthropologist's purpose was to understand how communication happened in the villages and how this changed during the television experiment. During the year of the programme broadcasts these anthropologists were responsible for gathering feedback through questionnaires, which were then relayed to programme makers who could adjust their content accordingly, much in the style of emerging models of market research. However the style of data gathering, as for instance described in a report for UNESCO in 1976 *Planning for Satellite Broadcasting* by ISRO technician and media producers Romesh Chander and Kiran Karnik, exposes the asymmetry with which non-village production teams, anthropologist and technical crews sought to design programming that would alter the behaviour of villagers. Programming and technology design appears to have been shaped through an iterative process of observation and feedback, but never it seems by giving over control of programming to the villagers themselves. The reports construct the audience in belittling terms; here the "illiterate farmer" is positioned as childlike:

> Where moving images on TV screen are concerned, the illiterate farmer in the tribal areas of Madhya Pradesh or Orissa in India, is in a comparable position to a child looking at a printed book for the first time. (Chander and Karnik, 1976, p. 28)

[152] Illich argues that 'global' ideas force subsistence livelihoods into the economic sphere of capital so that no exchanges happen outside of this economic system. He likens this move to the new idea of World Peace. Peace use to mean being left in peace but Illich argues this has been usurped by the totalising, global idea of World Peace. In this way Illich exposes the wrong-thinking of both ideas of World Peace and of Development and by showing how Development is habitually justified as a move that will bring World Peace suggests the de-linking of the two concepts because it is their linking that hides more subtle kinds of damage.

'Image perception studies' attempted to measure the ability of audiences to recognise time shifts in editing. In one image perception study the ability of audiences to distinguish real humans from animated characters is tested. The report concludes that many viewers, "carried away by the anthropomorphic qualities of the characters, excellent animation and characters" thought the animations were real. This kind of conclusion drawn from the surveys is typical of the inadequacy of the audience perception tests. Nowhere does the report provide an explanation of the ambiguity of the category of 'real' or delve into the specific meaning of such a question from within the audience's frame of reference for such philosophically complex concepts as real, imaginary, metaphorical, illustrative. A passage referring to this test from the *Planning for Satellite Broadcasting* report is revealing of the assumptions latent in the data gatherers' questions and analyses.

> Judging from the facial expression and emotional behaviour registered by the respondents during the screening it was obvious that the humour fell flat - most of the respondents did not even smile much less laugh. On the other hand one of the investigators stated that he burst out laughing every time he saw the cartoon – and he had seen the film at least 25 times. The behaviour of the respondents could be attributed to some extent to their being the centre of attraction; but according to the Project Director, it was mainly the result of their lack of familiarity with cartoons. (Chander and Karnik, 1976, p. 29)

If read through the lens of a subaltern studies methodology this passage also hints at a separate agenda being played out by the audiences, in response to their being observed. The extract for instance contains hints of the audience's cogniscance of the asymmetries within the whole process that render their own position subjugated in relation to the satellite technology. The passage contains a hint that there is suspicion that the satellite experiment and its gifts of television sets are part of a more hidden state agenda. From the behaviour of the audiences it is possible to glean that deliberate resistances are being used against the assumptions and presumptions behind the questions and experiments coming from the state officials who represent a 'foreign' urban middle-class. The audience is described as not understanding the humour of programmes, while the official gets the jokes, but it seems also that the writer senses that the results are being affected by the test itself, "The behaviour of the respondents could be attributed to some extent to their being the centre of attraction", perhaps that the audiences are not smiling because they are being observed for their reactions which they understand are being monitored. Here the writer provides a space for an agency to exist that is not fully being appreciated by the observers and is actively dismissed by the Project Director who interprets this as a lack of ability to comprehend a new, modern media. The Project Director assumes, "it was mainly the result of their lack of familiarity with cartoons" (Chander and Karnik, 1976, p. 29).[153]

The one-sidedness of the reports about SITE and their limited ability to portray the fullness of audience perceptions are slightly lessened in the anthropologist's texts that more seamlessly and accommodatingly account for the interplay between villagers, technology and the various interlopers to village life who accompanied the televisions. The anthropologists kept detailed field notes of all their conversations with villagers, which they were encouraged to leave in the original languages so as not to introduce any distortion (Agrawal and Vishvanath, 1985, p. 45). They also kept reflective daily journals with the overall aim of understanding patterns of communication within the villages and documenting changes in those patterns and village life in general in relation to the introduction of satellite television. Of these sources, many convey the story of the anthropologist's journey into the village often in a modality like that of a film, introducing their own entrance into this new world of the village by describing the train and bus journey, the transfer to bullock cart and their arrival as strangers in villages in search of lodgings. In one book, *Anthropological Methods for Communication Research: Experiences and encounters during SITE* (Agrawal and Vishvanath, 1985), the anthroplologist's nostalgia for time spent in the villages can be gleaned in the chapter titles, 'The Old Nizam Village' by MVT Raju, 'A Village by the Kosi River' by MN Jha and 'The Moments in Quietness' by Arnind K Sinha. The accounts contain anecdotes of the suspicion with which these newcomers were regarded as possible intelligence agents. In a sense the real ambivalence of their positions was

[153] Part of the rationale given for carrying out image perception tests is that rural audiences have not seen cinema and so will not understand the syntax of editing used in television. Film studies of audiences in India reveal many kinds of active resistances by audiences in response to propaganda films during the time of the British Raj distributed to cinemas and played before main features. The kinds of resistances described (Mohan, 1990; Narwekar, 1992; Garga, 2007; Gokulsing, 2013) such as standing up and interrupting the projection with one's own silhouette as well as talking during the screening were not accidental, but examples of the many kinds of deliberate disrespect or resistance constantly performed to counter state controls. It is suggested here that the SITE audiences were no less able to invent means of countering the transparent agendas of their government.

like that of a spy, in that friendliness was a means to obtain information about village life which then became passed on to the state institution of ISRO. The anthropologists formed deep attachments to village life and in some cases their sympathy for the rural populations as well as their much fuller understanding of the state project make these pivotal observers of a complex interaction not seen from other more official positions.

Amongst the anthropologist's field reports are moments at which the cogniscance of those living in the village of the agency or not of their own position comes through. It is a cogniscance not only of the programmes presented via the satellite televisions, but also of the much larger picture of themselves as recipients and players within a state sanctioned scheme. The following account of a joke made in a paddy field is one such revealing moment that in some ways inverts the subjected status that the villagers acquire in their representation in official reports. The text is about the anthropologist MN Jha helping to plant paddy:

> I was requested by Radha Krishna to plant paddy as demonstrated on the TV during paddy and wheat cultivation. Similarly, the maize planting process was directed by him. In the course of this he often remarked “you have watched on TV very good demonstration, but even then you are not doing it correctly”. (Agrawal and Viswanath, 1985, p. 66)

Radha Krishna's joke demonstrates his cogniscance of the part he plays within the new apparatus of satellite technology. He is a farmer being modernised by the state via the *Krishi Darshan* television programme. To a large extent this interference may be benign. Yet, subtly, his own values, status and relation to the natural world and farming techniques are in some ways undermined as he is modernised. Radha Krishna's joke implies it is the television, and not him, who is teaching the anthropologist newcomer to plant paddy and the joke goes further because the television conveys that it is not the people of the village, but outsiders who hold the knowledge on how to plant paddy. The outsider is teased for not being sufficiently modern. This teasing does not alter the ability of the farmer to resist the changes in his own behaviour that the state seeks. The farmer is required to plant paddy in a new way and plays out his role, but the joke is another kind of technology, one that restores dignity. It furthermore articulates the agency of Radha Krishna, if not to act, then to perceive. It is that ability to perceive from one's own unique position an array of determining affects and one's own position in relation to these, that the planner's or official's view fails to take account of. The image perception studies cannot accommodate the sophistication of a perception to which the originators of that study have no access.

A report written by technologist and science fiction writer Arthur C. Clarke substantiates the limitations of the official viewpoint of the planner, which although visionary, lacked the capacity to accommodate many kinds of interpretive flexibility. At the time of the SITE project Clark was living in Sri Lanka and was an active proponent and participant in the SITE project. He wrote in a chapter titled 'Satellites to Saris' (Clarke, 1988) of the benefits of space technology to rural India, which as Sarabhai also maintained could 'leapfrog' terrestrial systems of developed nations. Clarke evangelises the potential to achieve 'one world' through space technology through this book that is titled *How the World was One: Beyond the Global Village* (1988). His rationale for space technology follows the predictable targets of development planners to control the unpredictability first of the bodies of its population by controlling sexual reproduction and secondly the unpredictability of weather, "SITE's first order of business", he states, "will be instruction in family planning, upon which the future of India (and all other countries) now depends" (1988, no page number) and then goes on to say that, "the prosperity and sometimes the very existence of the Indian village will one day depend upon space technology", because satellites will be able, he claims, to predict the onset of the monsoon that is critical for farming. In this way the technologies of space become endowed with monumental abilities to solve the most intractable problems of state - the free agency of weather and populations.

Asymmetry in the structure of SITE

Was the vision of the planner crystallised into the satellite television experiment's massive technological infrastructure? If a specific vision was structured into the technology, authored by its planners, how did these plans and visions play out in the lives of those affected? At what points and in what ways were they re-authored, adapted or even inverted? These are questions that are raised by the SITE project and for space technologies in general. The hardware of space technology with its impressive arrangement in space and on the ground conjure an imaginary that lends itself to carrying impressive ideologies such as agendas of social change. But the asymmetry with which such development projects as SITE were undertaken was the subject of much discourse around the world at the time. In India much of this discourse was bluntly critical of the arrogant imposition of urban, middle class values onto rural populations. The co-founder of *Seminar* journal Raj Thapar (co-founder with and married to Romesh Thapar, cited in Chapter 1) wrote in her memoirs of her profound annoyance at Vikram Sarabhai's plan for the villages. When the pilot project in Kheda began she was asked to by Sarabhai to be an advisor but quickly sent back the TV she was given by ISRO frustrated by the misplaced expectation that she, urban middle-class, could comment on rural life, saying, "If your programme appeals to the villagers, they will watch it, if it doesn't they won't" (Thapar, 1991, p. 342). In his study of Sarabhai's influence in the development of nuclear technology, Itty Abraham comments incisively on the shortcomings of Sarabhai's social vision. Abraham points out that Sarabhai as a social planner had an insufficient grasp on the implications of his vision, that he lacked any knowledge of village life and saw the satellite scheme only in relation to a large-scale national agenda of development. Responding to a proposal by Vikram Sarabhai, which incorporates references to both nuclear and space technologies, Abraham writes:

> This was a radically new conception of the role of nuclear power, [and also satellite technology] but one which is less liberatory that it might seem at first glance.[...] There was no mention, for instance, of including within the purview of decision making any input from the communities being affected in this way: Sarabhai may have recognised society, and indeed may have been driven by a greater sense of the need to overcome poverty and underdevelopment, but there was no room for local knowledge or non-expert thinking within this system." (Abraham, 1999, p. 132)

Planned from a command-centre viewpoint, space technology was deployed in ways that obviated the local, personal, intimate and unexpected alterations that inevitably and necessarily must occur. What is seen from the top contrasts sometimes entirely with what is seen from below. *Seminar* journal was open to critiques of state schemes and the asymmetry with which development schemes proceeded was the concern of many at the time. The following excerpt from an article in a 1979 issue of *Seminar* reveals some of the reflexive discussions underway questioning the gradual and surreptitious embedding of political agendas through technology projects such as SITE. Here, social commentator Chakravarti Raghavan writes in an article titled 'The Right to Communicate' about the problem of deterministic effects of technical apparatus imposed on social contexts in which the asymmetric relations of persons to the technological is hidden in a cognitive realm:

> The centre-periphery relationship is characteristic of technology. Technology is more than technique or equipment and know-how as Johan Galtung points out. A specific social structure operating internationally, nationally and locally, and a cognitive structure of deep-lying assumptions about the organisation of space and time and knowledge of human relations and relations with nature go with techniques. Without them the techniques would not work. (Raghavan, 1979, p. 37)

The argument of Galtung (1978, pp. 5-6)[154] referred to here and applied to large-scale technological projects in process in India concerns what Galtung termed the 'structural violence' by which structures such as technologies promoted in subtle ways the ideological agendas from which they were formed. Galtung argued that such embedded agendas are difficult to see. A key area of concern for Galtung was the ability of a person to meet their needs using a particular technology versus the imposition of obstacles to achieving this end structured into the technology. He thought of technologies as having filters that allowed certain kinds of uses – and from this could appear to be beneficial – but filtered out other kinds of uses and applications. He noticed in the introduction of large-scale technologies an asymmetry in which hidden filters outweighed more visible benefits. His point was that this problem of asymmetry was often difficult to discern. Galtung presented his ideas in India. In a footnote to a paper prepared for

[154] The quote above derives from Galtung, "we conceive our technology as techniques plus structure, where the techniques have hardware components (tools) and software components (skills and knowledge) and structures are mainly of two kinds: economic and social structures on the one hand, and cognitive structures, deep-lying assumptions about reality, on the other. The assumption is simply this: whenever a technique is developed, deployed, transferred, a structure is being built, whether it is a technique for production, for distribution or for consumption. Hence, we shall use the term "technology" with the understanding that it is never "politically neutral" because it always carries a code, expressed in the structure accompanying it, social and/or cultural" (Galtung, 1978, pp. 5-6). The relevance of Galtung's theories with the development of large technological systems in the Indian context is indicated by a reference in a footnote. Galtung quotes Yash Pal (educationalist, ISRO technician and media producer) from 1976 Pugwash conference in which he says Yash Pal made "a strong plea for scientists and technicians to work with the people in the villages, and also reminds us that "appropriate science and technology is not necessarily archaic science and technology"" (Galtung, p. 7, footnote 34).

the World Order Models Conference in Pune, Maharashtra, India in 1978 he writes the following, which contains the urgency of his speculation:

> But how can techniques operate except through the medium of social structures, and how can the knowledge be developed and imparted without a cognitive matrix capable of embedding that particular type of knowledge? Moreover, given these structures the thesis also runs the other way: the structures serve as filters in the sense that only those techniques that are compatible with the structures will be accepted as serious candidates for social research and development - those that run counter to the dominant structures will at best remain marginal as something for peripheral groups, at worst be eliminated as archaic, or even as dangerous. (Galtung, 1978, footnotes p. 2)

Galtung's caution and clear anxiety about the 'structural violence' of technology draws attention to the less visible cognitive structures required by material technologies in order to work: the less visible extensions of technologies into and from persons. His theory was relevant to the building of large-scale technological infrastructures constructed in the name of benefit and need such as SITE and helps to indicate the mechanisms by which the project allowed certain kinds of engagement while ignoring or prohibiting others. Galtung also references in the paper quoted above the comments of Yash Pal who was part of the ISRO media production teams working on the SITE and Kheda projects. Pal went on to become a key proponent of new strategies for education and a prominent public figure. There appears therefore to be evidence for correspondence between Galtung's theoretical ideas about the surreptitious effects of technologies and the early use of space technologies for societal projects in India. Galtung's paper 1969, 'Violence, Peace and Peace Research' helps to point to the many kinds of less visible convergences present in this space. It is an important reference because he makes the point that structural violence does not show:

> The object of personal violence perceives the violence, usually, and may complain - the object of structural violence may be persuaded not to perceive this at all. Personal violence represents change and dynamism - not only ripples on waves, but waves on otherwise tranquil waters. Structural violence is silent, it does not show - it is essentially static, it *is* the tranquil waters." (Galtung, 1969, p. 173)[155]

[155] Galtung's comments were made at the World Order Models Project conference in Pune (then Poona) in 1978, a conference from which the "Poona indictment" was made heavily criticising the violence of structures of science and technology towards subalterns. So Galtung made the remarks that transferred into the Seminar journal in India, in Poona in 1978 and referenced a speech by Yash Pal. To guage the strength of feeling amongst those at this event see Weeramantry (1998) *Justice without Frontiers* on dissatisfaction with technologies in the developing world and this description of the Poona Indictment,

The purpose here has been to understand SITE as it appears through documentation as giving an enhanced understanding of the depth of complexity present within the shallow interface in which the large infrastructure of space technology comes into the intimate space of the person. The project has a visual imaginary and an optics – an arrangement of persons and technology – that produces this imaginary, which in turn structures the meaning and uses of the technology, determining what it is perceived to be and who should use it and how. What haunts the project of SITE is the sense that the villagers to whom it was addressed never fully owned it. Instead, the design was structured by assumptions from elsewhere, which arguably crystallised within the technological structure itself. The planner's view as given by figures like Arthur C. Clarke reveal an unpleasant objectification, the kind of structural violence commentators like Galtung and Yash Pal had noticed could be perpetuated by the imposition of large scale systems, that carried specific cognitive expectations which surreptitiously devalued ways of life by limiting crucial dimensions of personal choice and values.

So the televisual space of the screenings and the programme making, including the modulations criss-crossing the process through various feedback mechanisms, the perception of the programmes and the architecture of watching and being watched, can all be understood as a complex space of negotiation. That space of negotiation – between the space and ground located infrastructures of the organisational sphere of the space agency and the worlds of the villages – appears as a thin interface between screen and viewer, tiny in comparison to the vast spaces suggested by satellite architecture of spacecraft orbiting in the outer reaches of the planet, of rocket launches and huge dish antennas set in landscapes. The imagination of the space technology architecture all but obscures the vulnerability and subtlety of this interactive space in which the person and the spacecraft in some way brush against each other.

"This Declaration was adopted at a meeting of the World Order Models Project held in Poona, India in July 1978. The Declaration, titled "The Perversion of Science and Technology: An Indictment" recited that it was "an indictment of the way in which science and technology has become instrument, of a global structure of inequity, exploitation and oppression" (Weeramantry, 1998, p. 64). See also Reid and Taylor *Recovering the Commons: Democracy, place and global justice* (2010) where it is stated that Ashis Nandy and Rajni Kothari were among the signatories (2010, pp. 220-222). While Galtung does not refer to SITE, the project can be positioned as a social and technological innovation situated within this polemic worldwide discursive space

A postscript to SITE

The founder/editors of the influential journal *Seminar*, Raj and Romesh Thapar, as has been indicated were critical of Sarabhai's ability to conduct a 'societal' space programme based on their understanding of the limitations of the vantage point of the middle-class planner to account for the choices and needs of a different cultural perspective (Thapar, 1991, pp. 342-343). In 1978, Raj and Romesh met with a small team from ISRO's Satellite Application Centre still working with the satellite television project in its smaller scale residual form in the district of Kheda. They were struck by the gravity of the insights of the team of media producers and decided to devote an entire issue of *Seminar* to what was taking place in this marginal and soon to be discontinued Kheda TV project of ISRO. The Thapar's were struck by team's ability to allow the people in villages to use the technology to direct attention to and solve issues that mattered to them. They noticed an inversion of terms of agency: that audiences had become producers and were using television to solve problems in their own localities. The issue of *Seminar* journal that came out as a consequence of the meeting was titled Another TV.

In brief the documented actions are of a collection of events that demonstrate innovative and freely determined use of technology by recipients. These actions stand out as remarkable instances of agency given the more prevalent terms of the viewing experience previously described. The activities described in the issue of *Seminar* journal do something else too; they provide a precedent to the actions of Moon Vehicle. There are similar types of intervention that occur. An art college for instance becomes involved – the National Institute of Design in nearby Ahemdabad. Similar conclusions can be drawn about the circumstances that led to these creative interventions. The links between creative actions and tactics of resistance demonstrate a similar pattern to that already identified and evidenced through the main case study of the thesis presented in Chapters 2, 3 and 4. What continues to be emphasised in this chapter is a sense of how the visual in its most expansive sense works as a determining layer through the affective realm of space technologies.

The format of *Seminar* journal is that each issue addresses a central problem and all the articles in that issue discuss that problem from a different perspective. The issue called Another TV is slightly different because Raj and Romesh Thapar, the editors, gave the whole issue over to the ISRO team to describe their "excellent work" (Thapar, 1978, p. 11) so that their practice could be disseminated more widely.[156] Here the group leader Yash Pal introduces the team, he writes:

> We work at the frontiers of space science and technology [...] We can develop technological systems for potential applications. Or we can get involved emotionally, intellectually and experimentally with specific human, social and economic problems and work at the technological elements. (Pal, 1978a, p. 12)

He goes on to say that the team follows both paths, that they integrate the technological with the human and emotional, but that, "For many of us the second route [the emotional route] has more meaning" (1978a, p. 12). Pal shows that it is this fragile interface between technologies and persons in the specific contexts of their lived experience which motivated the team to work on the SITE and Kheda TV projects and he conveys the daunting complexity of this task and his trepidation in attempting as a creative media producer, educationalist, scientist and technologist to find the usefulness of the technology, or more accurately, to find a way in which "specific human, social and economic problems" might find a usefulness for "technological elements". Pal's writing is full of doubts as to what the team might be doing to village cultures unknowingly by bringing in space technologies. They found a framework to proceed by working collaboratively through networks of enthusiasts from many backgrounds and by constantly revising their assumptions and modes of working. Pal identifies the dangers of the changes they could have been unwittingly enabling as the ambivalence by which a satellite system "*potentially*" (emphasis in the original) "can be developed for preferential treatment to

[156] Raj Thapar describes meeting with the team from the Satellite Applications Centre in her memoir (1991). She did not think much of ISRO's rural development projects and describes her dismay at the attitude of Vikram Sarabhai in establishing a system that only reflected his inadequacy to comprehend the world view of the village lives he sought to change (Thapar, 1991, pp. 342-343). She was however deeply impressed by the group she and Romesh met in 1978 because they seemed to be moving beyond such problems and giving the technology back to the villagers themselves. She writes of the meeting, "It was such an unusual and moving experience" (1991, p. 451). She felt that finally something right was happening and hence the decision by her and Romesh Thapar to devote an entire Seminar issue to their work. Part of the necessity was that the extraordinary work of this team was that the project was near the end of its funding. It should also be noted that these events happened after The Emergency imposed by Indira Gandhi in which the government implemented extreme forms of censorship on citizens. The editor's intense preoccupation with citizen freedoms can be understood in this context.

those sections of the population which normally only get the dregs of development" (Pal, 1978a, p. 14) but equally can be used "for homogenisation, indoctrination and for the control of the minds of the many by a few". What it is that he recognises needs attention in this technological system that harbours such potential danger of misuse is sensitivity to, "an intimate milieu, with close kins and near neighbours, and the daily business of growing up, learning and living with local sounds and smells". In other words, Pal's idea is to ground the use of space technology in the intimate spaces and vantage point of the everyday. What seems to hover through his introductory essay is a sense that perhaps the image of the structure of space technology needs to be countered by such things as sound and smell to emphasise the intimate and phenomenological that is too easily obviated by the satellite and its impossible to experience and grandiose imaginary. Yash Pal writes compellingly about a space of interaction that although close to and in everyday space is somehow harder to see than the iconic satellite in space even though the everyday is so real and the satellite in space only imagined.

Three anecdotes are briefly presented next taken from the same issue of *Seminar*. They describe events, incidents and activities at the slight space between the television screen and the viewer that it is argued in this thesis is a crucial but overlooked part of the space technology system. The first is in an article called 'Participatory Software' written by E.V. Chitnis in which a description is given of how students from the art and design school in Ahemdabad, the National Institute of Design, collaborated with ISRO in the production of programmes that became absorbed into village life. In much the same way that students from Srishti interacted with ISRO personnel and combined their diploma projects with opportunities that emerged from the network of practice that came about through the Moon Vehicle project,[157] so too it seems did a similar affiliation come about during the seventies as ISRO developed its satellite communication infrastructure. Chitnis describes:

[157] While small numbers of students worked directly with me on Moon Vehicle projects around a hundred students took courses and developed personal projects during the development phase of the festival of astronomy, 'Kalpaneya Yatre'. For this they researched with astronomers at the Indian Institute of Astrophysics, the Raman Research Centre and ISRO, creating a range of exhibits, films and participative or performative new works. A short film documenting the festival is available at YouTube (Poomulli, 2011).

> For one of the NID student's diploma projects, we provided portapacks [portable cameras], production crew, editing facility and guidance for formative work and production techniques. The idea was that the student-producer would design a small series of programmes with a definite goal for a given target audience. She decided to develop a children's series, after extensive discussions with her formative researcher and producer guides and visits to villages, spending considerable time with children and talking to their parents. (Chitnis, 1978, p. 24)

Another student developed a series using puppets, which “regularly received invitations to marriage celebrations from the villagers," (Chitnis, 1978, p. 24). This collaboration between art college students and ISRO, albeit a particularly creative wing of ISRO, indicates the spread of enthusiasm for participation that this new opportunity presented by the development of space technology allowed. It demonstrates moreover a push towards the establishment of creative space and localised negotiations that included technological elements. The artistic-led practice that could easily be accommodated in this interactive space indicates a space for "interpretive flexibility" (Pinch and Bijker, 1987) of space technology coming from the ground-up rather than top-down.

The second anecdote follows this pattern of agency. In this example the broadcast media is used to highlight negligence by state authorities to fix a problem with the water supply to fields. Producers and farmers collaborated to visualise the problem on film and then due to a series of serendipitous meetings use this as a political vehicle to expose the grievance ultimately leading to the problem being fixed. It can be inferred that the serendipitous meetings came about because as part of the technological system being installed, communities not usually in contact with each other had come together. So villagers now were on friendly terms with sympathetic producers who moved in circles with officials of the state. Much as the Moon Vehicle project described in Chapter 4 used events such as '100 Days of CHN-01' to create links with the Chandrayaan scientists that then brought about joint projects between these scientists and children living in slum neighbourhoods adjacent to the space agency, so too, the activities associated with the installation of space technologies in the mid-seventies produced new social networks in which new spaces of agency could be taken advantage of at this confluence of the innovative, creative, socially sensitive and technological. The contingent events and the opportunities they opened up are described in this way, again by Chitnis:

> It so happened that senior officials and members of the Gujarat Government had invited our producer for the making of a particular TV documentary. When our producer and researchers met them, they decided to show them the 20 minute documentary on the villager's irrigation problem. It had an electrifying effect and that august assembly felt that something startling had come to their knowledge. Kheda TV then arranged a meeting of the aggrieved farmers with the highest concerned who immediately instructed the officials to take steps to solve the problem. (Chitnis, 1978, p. 23)

Here the idea of a societal space programme consisting of a technology that could be used to solve local problems by local people appears to have achieved its goal.

The third anecdote illustrates a moment when the recipients of the television programmes distributed through the technology of ISRO take command of the media themselves and conceptually localise and personalise the space system by becoming both subjects, actors and producers. Media producers in consultation with villagers generally scripted programmes. At a certain point actors in the programmes became the villagers themselves because of a lack of funds to pay professionals. However the actors, the villagers, would then naturally start to use their own words, and knowing the situations being depicted better than the producers simply ad-libbed their own words and improvised the action, leading to a redundancy of the media producers and cutting out this intermediary. The turn of events is described by one of the media producers in this way:

> The whole rehearsal was allowed to develop with no holds barred as to techniques of acting, technology of shooting or equipment constraints. It started dawning on many of us that the problem was theirs and the performance was theirs and finally whatever was captured on the video tape was going to be theirs. (Vishwanath, 1978, p. 30)

As with the historiographic essays of the subaltern scholars, the authentic voice of the person from the village is not directly available, but something of the actions, wishes and presence of that perennially missing voice is available through the voice of the intermediary, sympathetic media producer. It is enough to indicate a space of agency that unfolded or became apparent through a course of activities that moved from a less determining to a more determining influence for the village society to which the space agency was directing its technological capability.

What is cautionary however is that this kind of agency at grass roots level was so rarely documented or recognised. These moments appear in documentation as startling moments in which subaltern viewers grasp an authorial agency. They are like the kinds of glimpses that the subaltern historians struggled to restore into more visible and comprehensible frameworks so that they would not be lost to future generations but could also inform current thought. So too, these anecdotes, or glimpses, are brought to the surface in this thesis because they are all but lost artefacts which help to indicate that the more contemporary events of the Moon Vehicle project were not without precedent and in bringing them to the surface they help to establish the artist-led interaction as a much more robust, well-informed and necessary action than it felt at the time. At the time the project, rejected by officials in ISRO and in danger of being relegated as an artistic and therefore low priority form of education felt fragile, vulnerable and in many ways negligible. The precedent of these equally fragile glimpses within documentation from the 1970s, which are indicative of technology as sometimes the site of social struggles, as sometimes incidental in the flow of everyday life, as sometimes a vehicle for creativity and entertainment, indicate that more significance can be attached to the artist-led intervention than has been acknowledged.

The fragility of the glimpses, their *darshan*, is that they point to a state of lived experience, an affective space in which things pass through us. A vitality of which the social theorist Brian Massumi writes, "Actually existing, structured things live in and through that which escapes us" (Massumi, 2002, p. 36; quoted in Thrift, 2004, p. 63). The glimpses afforded by the understated joke made in the paddy field or the urgency of the ISRO scientist/media producers writing in *Seminar* journal, give witness to vital and resistant encounters with ISRO's space technology in social spaces where they happen in reactive and unprecedented moments incapable of pre-definition and always beyond the purview of the planner.

As a way of drawing together threads that have indicated conflicts and marginalisation, the chapter closes by presenting a model that affords a more substantial position to the subaltern. This final section of the chapter presents a re-shaping of the asymmetries identified using a theoretical model proposed by Dipesh Chakrabarty written twenty years after his first contributions to the Subaltern Studies Group were made. It draws on insights from subaltern studies to propose that apparently missed voices and viewpoints are already integrated into the dominant narratives from which they are seemingly excluded. Chakrabarty's model provides a staging with which to reinstate subaltern experience and viewpoint into a dominant narrative of spacefaring. For the argument of this thesis this modeling helps to move the analysis of the thesis towards developing an apparatus for seeing better aspects of the accountability of spacefaring.[158]

Reinstating the subaltern: Can the subaltern be seen?

Dipesh Chakrabarty, who participated in the collective work of the Subaltern Studies Group, has continued to develop ways to address asymmetries in knowledge, through the discipline of history and postcolonial discourse, as have others associated with the group.[159] In many ways his purpose has been to tackle an 'optical error' (1983, p. 195) concerning the mechanics of who is seen and not-seen, who is included or excluded. As part of a postcolonial discourse, Chakrabarty has sought to understand processes of sublation, whereby a perspective, difference, a way of life becomes overlooked by its absorption into a universal. In a chapter from his book *Provincializing Europe*, Chakrabarty looks at whether "the logic of capital sublates differences into itself" (2000a, p. 50). Sublation is a philosophical term for the dissolving or assimilation of a lesser entity into a greater and it is used by Chakrabarty to enquire how and whether critical theory emerging from the European context should be applied outside of that context. His questions are around whether non-European cultural experiences become sublated through the

[158] It can be noted here that the use of subaltern studies in the thesis has motivated a discussion of agencies and resistances, in particular the optics or visuality that can be associated with actions and affect rendered invisible for reasons such as social and cultural differences and methods of history writing. Historian Rosalind O'Hanlon's critique of subaltern studies points out some shortcomings of the subaltern studies project which are also relevant to the line of argument taken in this thesis. O'Hanlon suggests that there is a distortion of the subaltern subject because the writing is, "in terms of liberal humanist notions of subjectivity and agency" (1988, p. 191). She points out that the writers are themselves searching for agency and resistance because they themselves value these qualities. It could be argued that the artist has an even greater propensity than the liberal historian to look for and reinstate lost and forgotten moments of resistances and self-expression. Thus my own use of the idea of the subaltern is liable to be corresponding author-centric.

[159] Papers by Gayatri Chakravarty Spivak (Guha and Spivak, 1988; Spivak, 1988), Gyan Prakash (1994) and Dipesh Chakrabarty (2006b) reposition subaltern studies as part of postcolonial discourse

assimilation of European thought and he is particularly concerned about the adoption of the thinking of Karl Marx in the Indian subcontinent.

Through subaltern scholarship the concern has been raised as to the likelihood or not of the subaltern viewpoint being included in the logic of space enterprises. Chakrabarty's discussion of Marx's capital helps to make this clearer. Before examining his argument more closely, a widely referenced paper by another scholar of the Subaltern Studies Group, Gayatri Chakravorty Spivak will first be introduced that directly confronts the question of the inclusion of subaltern viewpoints. Spivak's essay 'Can the Subaltern Speak*?'* (1988) moves subaltern discourse into the field of postcolonial criticism. In this essay Spivak takes a pessimistic view as to the possibility of altering processes by which difference is sublated into universals, exposing the consequences of sublating heterogeneous circumstances into assumed universals. In her argument she takes issue with the seeming banality with which the terms 'the workers' struggle' and 'the Maoist' are used in a conversation between Foucault and Deleuze as if they are terms that could be universally applied and understood.[160] The assumption of a universal workers' struggle could for instance be challenged with reference to Chakrabarty's essay 'Conditions for Knowledge of Working-Class Conditions' (1983) that gives substantial evidence for the lack of commensurability between the working classes in England and India in the 1800's. Spivak denounces the "baleful ... innocence" (Spivak, 1988, p. 67) with which these references are made by such powerful intellectuals saying "The apparent banality signals a disavowal" (Spivak, 1988, p. 67). Spivak goes on to use the compelling example of *sati*, the practice by widows of burning themselves on the pyre of their husbands, which was condemned by the British Raj, to illustrate how the debate of this controversial practice obscured the perspective of the woman herself. Spivak's seminal essay *'*Can the Subaltern Speak?' links the insights and empirical evidence of subaltern studies to larger problems in the currents of discourse that elude definition. The elusive disavowals made by Foucault and Deleuze to which Spivak refers such as the anonymity of the reference to 'the Maoist' Spivak suggests, "creates an aura of narrative specificity" but in its enlargement, "symptomatically renders 'Asia' transparent" (Spivak, 1988,

[160] The text she refers to is 'Intellectuals and Power: A conversation between Michel Foucault and Gilles Deleuze' (Foucault & Deleuze, 1988).

p. 67). Spivak maintains that such loose terminologies appear as almost negligible banalities, but that a banality, lightly placed, can become the 'disavowal" of a continent. Spivak exposes a limitation in the European philosophers' purview and goes on to expose a similar limitation in perspective in her discussion of *sati*. In discussions of *sati* Spivak notices how a misrepresentation of experience occurs in the translation from the first-person (the widow's experience) to the second or third person (the experience as perceived by family or the state). In the inevitable loss of the authentic 'first-person' experience, in Spivak's argument, goes the ability of the subaltern to speak.[161]

Chakrabarty's path to unravelling similar issues of incommensurability leads him to also examine how European thought, through such chinks, disavowals and assumptions has come to be used outside its originating European context to analyse problems in non-European places such as India. To do this Chakrabarty examines universalising concepts used by Marx in his Theory of Capital and finds that what he had assumed to be incommensurable differences in the conceptualising by Marx of 'universals', may indeed have taken account of and encompass difference. To explore this Chakrabarty presents a model that he calls "History 1 and 2's" which offers a more optimistic way forward than Spivak proposes to the possible sublation or not of the subaltern voice and viewpoint. It is a model that can help reinstate the modality of the subaltern to enterprises of spacefaring. Rather than conclude that the subaltern cannot speak, his model has the effect of foregrounding the inflection of the subaltern. He does this by examining a reference made by Marx to the history of 'capital', which seems to Chakrabarty to be "underdeveloped" (Chakrabarty, 2000a, p. 66). What he notices in a passage by Marx in the posthumously published writings *Theories of Surplus Value* (1863) is that Marx posits a history of capital that includes whatever can retrospectively be interpreted as having produced 'capital', plus, "antecedents" that did not themselves contribute to the logic of capitalism. It is from this double formulation that Chakrabarty makes his terms History 1, "a past posited by capital itself

[161] Gayatri Spivak's argument is complex and I am interpreting the general claim of her question, which asks if a first-person voice can be listened to and accounted for, or why certain voices are so repeatedly lost. To this question she draws the negative conclusion, "The subaltern cannot speak" (Spivak, 1988, p. 104). In her argument she thinks through Derrida to formulate this conclusion and finds fault with Foucault and Deleuze who, despite the liberatory politics implicit in their intellectual work, fail to account for their insufficient recognition of the influence of their own social, cultural and authoritative power.

as its precondition" (2000, p. 63) and History 2s, which, following Marx's term 'antecedents', are not necessarily part of capital's becoming, but are nonetheless woven into its history. In Chakrabarty's formulation of History 1 and 2s, drawn from the account Marx describes of the history of capital, 1 and 2s are not separate histories. They are not as simple as a 'dominant' or 'subaltern' narrative, but instead in a dynamical relation. Chakrabarty explains the crucial interconnection he perceives in Marx's understated comments in this way:

> I therefore understand Marx to be saying that "antecedent to capital" are not only the relationships that do not lend themselves to the reproduction of the logic of capital. Only History 1 is the past "established" by capital, because History 1 lends itself to the reproduction of capitalist relationships. Marx accepts, in other words, that the total universe of pasts that capital encounters is larger than the sum of those elements in which are worked out the logical presuppositions of capital. (Chakrabarty, 2000a, p. 64)

The phrase a "total universe of pasts" is relevant to the subaltern and 'superaltern' production, use and history of space technologies. It provides a cautious step back in to the idea that a unity is posited by spaceflight. This cautious step requires a different imaginary of unity than those provided for instance by the Whole Earth image or the gesture of the astronaut in space vicariously representing the species. This cautious step back towards an imaginary of unity requires an interpretation that allows for more organic, less pristine and altogether messier associations. The imaginary shape made by History 1 and 2s is an entwined and interconnected structure and as such begins to approximate such an organic, disordered model. What Chakrabarty's model offers is a combined history of dependency – all that by which spacefaring has been constructed – and non-dependency – all that not involved in its construction but which needs to be there in order for spacefaring to exist. To transfer the argument or model by substituting the universality inherent in the idea of spacefaring for that other type of planetary universal, called 'capital', is to suggest a shape of dependency for space technologies that includes all involved in its construction - the space agencies - as well as 'antecedents' - those subalterns of the production of space technologies, who are nonetheless implicated and nonetheless necessary and in some ways also determinants of space technology.

The shape of this entwined model seems to allow for a more substantial place and role for the subaltern. It tilts and disperses agency in new ways. The asymmetrical position of the subaltern is not passive but charged. The pattern of negotiation is not that of two parties in opposition, almost as if situated on a plain in adjacent fields, only able to meet at their edges. The entwined shape banishes that mental model and the imaginative limitations of the binary opposition. The geography or topology of the problem re-forms. Chakrabarty here suggests how the entwined shape dissolves the obstacle of the boundary and just as significantly how this modeling resists sublation, whereby the lesser would dissolve into the greater without trace:

> In other words, History 1 and History 2, considered together, destroy the usual topological distinction of the outside and the inside that marks debates about whether or not the whole world can be properly said to have fallen under the sway of capital. Difference, in this account, is not something external to capital. Nor is it something subsumed into capital. It lives in intimate and plural relationships to capital, ranging from opposition to neutrality. (Chakrabarty, 2000a, pp. 65-66)

Here, Chakrabarty liberates a certain weight from the writer of alternative or revisionist histories, because here is the suggestion that instead of making difference dialectical and in that way a by-product or reject from a master-narrative, difference of many sorts is always within the nature of everything, "History 2s do not constitute a dialectical Other of the necessary logic of History 1" (2000a, p. 66). There are no boundaries formed, or sublation of the weaker into the stronger. Furthermore, the refreshing and positive thrust that Chakrabarty's argument gives to the problem examined in this thesis of the inadequate account given of subaltern experience produced by spacefaring, is that it gives agency to the subaltern position. The subaltern can speak and see and experience. Moreover, the shaping appears to give the advantage to History 2s, which are the "charged" elements of the relation. Chakrabarty's rethinking of the meaning given by Marx to the 'universals' his theory of capital assume to be in operation, in summary leads him to consider the following:

> This is the possibility that I suggest Marx's underdeveloped ideas about History 2 invite us to consider. History 2 does not spell out a program of writing histories that are alternatives to the narratives of capital. That is, History 2s do not constitute a dialectical Other of the necessary logic of History 1. To think thus would be to subsume History 2 to History 1. History 2 is better thought of as a category charged with the function of constantly interrupting the totalizing thrusts of History 1. (Chakrabarty, 2000a, p. 66)

These reflections invite an encompassed story to be told of the "intimate and plural relationships" that can be found to constitute spacefaring, The segregations formed by the architectures of the organisations, technologies and expertise that constitute the ostensible logic of spacefaring need not form the imaginaries of the affective space of spacefaring. The visible clues gleaned from spectatorship need not necessarily form the social relations of these enterprises. Demonstrably, they do and this is the problem that this thesis has addressed. Time and again the organisational power and control of space agencies, given form in their architectures of ground based installations and space-travelling products, are found to have diminished a less visible subaltern. But in the model presented by Chakrabarty the subaltern position is not separated or annexed and this inclusion of subalternism within structures from which it is apparently excluded invites a rethinking of the imaginaries that structure both participation and non-participation in spacefaring.

Summary

The delimited spaces for creative intervention and re-interpretation of space technologies are an enduring problematic in the projects of spacefaring. This delimited space could be understood after Galtung as a "structural violence" that filters out certain forms of participation, certain values or uses. This chapter has used insights from subaltern studies to show a genealogy to the Moon Vehicle project presented in Chapter 4. The indication of other kinds of creative intervention occurring earlier in the Indian space programme and involving in one case students from an art and design college show how creative approaches are a part of processes of 'figuring out' technologies.

The chapter has foregrounded in several ways that there is an optics or visuality to subalternism. The references to optical problems made in subaltern studies historiographies clarify how technology and persons are arranged. This has been used to argue that the arrangement of space technology produces subalternism. The visual imaginaries of a grandiose satellite system are instrumental in producing subalternism. The comparative fragility of the thin spaces of interaction between the screen and viewer/recipient nonetheless take on a compelling status as spaces of overlooked or inhibited agency. The nature of agencies present in such fragile spaces of interaction with space technologies, once opened up through attentiveness to the optics of the subltern viewpoint and the visual imaginary of the satellite system, becomes available for critique.

The societal programme of India made the radical move of redefining the imaginary of who spacefaring was for and this shift happened primarily as a result of the SITE project. The critique made of the SITE project here is a continuation and an addition to a critique of who spacefaring is for. The Moon Vehicle project as described in Chapter 4 was also presented as a continuation of that critique in that it responded to a perceived failure in the societal programme, that paradoxically became evident at the point of launch of the Chandrayaan spacecraft. That spacecraft, which broke away not only from the Earth but from the philosophical potency of the societal programme, provided an interruption to the logic of accountability, of the societal remit, through which to ask a very similar set of questions. Such questions were also raised by the SITE project. The legacy of SITE presents a problem, because the liberatory glimpses described did not form part of that legacy. The idea of art colleges working with ISRO, of villages making their own programmes and inverting power structures remained outside the mainstream meaning of societal in ways not easily seen. Recent publications and the recent policy of ISRO indicate the filtering of choice and the delimiting of space of agency continue to accompany the rhetoric of the success of the societal programme. In the 2007 publication *Touching Lives* (Das) an intermediary official voice once again prevents the authentic voice of the recipient from being heard in its fullness. The model of benefit and use that endured to a great extent overlooked the richness of interaction that could be encompassed in the televisual: that the intimidating external visuality of the satellite system could be short-circuited using television so that the viewer could in effect enter the system and view himself or herself on TV.

Instead, the interpretive flexibility of the technology congealed at a slight distance from the television viewers, at a point that could better be understood as that of the official or the anthropologist, sympathetic to the audience, but unable to devolve their own experience. The viewpoint feels trapped as if in the vision of the intermediary clerk penning communications between officers and foot soldiers. The model of interaction – History 1 and 2's – gives the subaltern voice, visibility and agency by offering a reflective route out of this quandary. Its abstraction provides a temporary staging from which to rethink how the vitality of forces presented in the technography of the spacecraft could now be channeled.

Chapter 6

A modality for seeing space technology: The technographic picture

The reinstatement of subaltern viewpoint posited in Chakrabarty's model of History 1 and 2's allows for a subtle interplay of subaltern agencies in the formation of narratives of history. The revisionist historian finds a surplus or excess in history itself, an unaccounted for 'dark matter' of influence, present, although not easy to perceive: the unrecognised inflection of the subaltern. Chakrabarty's formulation makes allowances for things to have influence that are not overtly or visibly a part of the logic of a particular history or a particular sphere of production. In the model presented by Chakrabarty the subaltern position is imagined as so profoundly embedded in that from which it is apparently excluded that there is moreover a sense of its necessity. The necessity of the subaltern – like the court jester to the king – can be oppositional and critical, seemingly irrelevant yet at the same time close and influential. The interplay between subaltern and superaltern could be imagined as archaeological fragments found to be present within the same field and apparently connected yet complicating the researcher's ability to arrive at a complete picture. The subaltern presents an anomalous relation but is never separated or annexed. Instead the activities of the subaltern that make visible a counter-force or the existence of antecedents apparently in opposition to the logic of the whole, invites a rethinking.

The anomalous presence of an artist in the technoscientific workplace gives visibility to the notion of an outsider but in the same instance signals the already existing presence of a seam of alterity within the logic of the technoscientific workplace itself. Within the workshops and encounters of the Moon Vehicle project described in Chapter 4 is evidence of the co-production of meaning given to space technologies. Arguably such meaning-making would not have existed without the intervention. The artistic approach gave a license for the affective space of the technology to receive attention in ways not normally included in the social domains of the space agency. But arguably the evidence of affect, of meaning-making and personal reflection brought to the surface through creative methods was not confined to workshop participants. Rather, the artistic approach caused a friction that made evident the presence of an affective space that otherwise remains generally unacknowledged and invisible, a seam of experiences which became available coterminously with the production of space technologies. Such spaces of affect, cast as ulterior and hidden from view, can be considered to constitute a subaltern experience of space technology. The existence of such spaces of affect pervade and interrupt spacefaring enterprises jarring against the apparent clarity of purpose attested to in mission rationales and jarring against the established hegemonic practices that mould the technoscientific workplace.

What has been arrived at through the writing of the technography of Chandrayaan and via a reflection on subaltern viewpoint is a sense of a pervasive secondary form of production accompanying the production of space technology. This is the phrase used by de Certeau (1984) and referred to in the Introduction by which he identified that within activities of the everyday, most usually overlooked as unsophisticated, irrelevant or ignorant, were complex processes of assimilation and resistance, often very deliberately hidden, which defied extrapolation or interpretation yet constituted a majority experience.

Artistic projects are not necessarily everyday activities, but just as de Certeau considers conversation to hold critical and creative agency, so too, art practice provides a medium by which to make visible and also create spaces of reflection, resistance and interpretation that otherwise lie under the radar. Moreover artistic practice is a medium like conversation that develops thinking and provides a means for unformed thought to become articulated or for half-acknowledged experiences to become substantiated through acts of authorship such as performance, drawing and the making of artefacts. The artistic projects presented, necessarily involved conversational dialogue and included types of social and geographic mobility that accompanied research and interpretive work leading to creative translations. The act of exposing the presence of such critical and creative agencies can furthermore be used deliberately. The artistic approach provides a demonstration. It specialises in producing visibility through combinations of methods that employ visual alacrity to demonstrate the existence of affective space. Artistic methods and approaches create an apparatus that can bring to the fore experiences, viewpoints and affect that complicate and interrupt habitual notions of the purpose of spacefaring.

It is argued here that a subaltern aesthetic was accessed through the artistic practice devised in the Moon Vehicle project and through the method of analysis devised in this thesis that draws on visual analysis and the social study of technology. The properties of visibility and visuality that arise from such methods and approaches are not obvious. The kinds of visuality afforded by the artistic approach are clear for instance in the production of artworks or performances. But many pervasive aspects of visuality are themselves invisible or at least immaterial functions of imagination, memory and the synaesthetic flow of the visible through thought, actions, senses and experiences.

In this chapter some qualities of visuality are delineated. These are not general qualities but qualities emergent with the kinds of visual alacrity that the author deliberately used as part of the activities of the Moon Vehicle project, described in Chapter 4. Qualities of visual alacrity used in the Moon Vehicle project are linked first with practices that have been associated with other artists, performers and cultural workers who have been driven by a need to demonstrate heterogeneous experience and viewpoint. The connection between real-world activities and the duration of imagination, which can be deftly crafted through creative practice, is further linked to qualities of light associated with spacefaring that impinge on what is perceived and imagined. This link strengthens the assertion made in the thesis that qualities of viewpoint and experience foregrounded by the artistic approach adopted by the author open up new areas of understanding the interplay between space technology and social domains. Methods of visual analysis developed through art criticism are used to propose how a subaltern aesthetic permeates spacefaring. This discussion then leads back to the technography described through the thesis, which is re-imagined in the light of the discussion as a 'technographic picture'. This move is a key original contribution of the thesis.

Visual alacrity

In many ways an analytical approach to considering visuality, which includes both visual thinking and visual practice, is counter-productive. The elisions of visuality, by which is meant the lack of separation of the visual from other experiential senses, is better conveyed through more poetic media such as prose or painting. There is for instance a passage written in *Ulysses* by James Joyce (1922) in which the character Stephen crosses Sandymount beach seeing, hearing, walking and thinking to himself through an internal monologue in which the seamless elisions of the "Ineluctable modality of ineluctable visuality" (1922, p. 61) are effortlessly evidenced.[162]

The expansive and experiential meaning of the visual is referred to by cultural theorist Mieke Bal in her perceptively written survey of visual analysis (Bennet and Frow, 2008, Chapter 8) as the "synaesthetic" qualities of the visual. She also refers to the "impurities" of visuality (2008, pp. 170-171) by which she means the constant mixing, or contamination, of the visual by other experiences. Artistic practice itself has been shown in this thesis to be a tool of visual analysis working as a diagnostic to indicate short circuits in the connections to space made available through space technologies. Artistic practice can provide a means to gauge the presence of codes for looking or not looking that indicate passages of access and restriction. In her summary of modes of visual analysis Mieke Bal hints at this way of thinking about visuality as through the eyes, experiences and thought processes of the practitioner, saying, "Here, visuality is a tool of analysis, not an object" (2008, p. 177). Generally, visual analysis studies the objects of art practice, such as exhibited drawings, paintings and installations with less consideration given to the phenomenology of art practice in itself. Nonetheless, art practice itself can be used as a tool

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[162] Nicholas Mirzoeff refers to this passage in the preface to his book *The Right to See* (2011, p. xiii),

of analysis. Drawing, for instance, when it requires clear lines of sight to the object being drawn, reveals the operation of mandates to look, or controls on what can and cannot be looked at by whom. This includes being witnessed revealing mandates to look, or being seen to be seeing. Artistic practice – or the experience of being an artist, of making a drawing or of developing a performance – may be a less obvious tool for analysis to the non-artist than the products of artists in the form of say an object or image. Bal herself is an exhibiting artist and while her commentary on the field of visual analysis puts focus on objects or images produced rather than on what it feels like to be an artist producing objects or images, she does makes a strong call for the act of seeing to be considered as analytical, interpretive and agential (Bal, 2008, p. 177). What motivates a drawing, what is seen and thought as a result of the focus enabled by drawing and what else comes into view as a surplus effect of drawing, performing or other kinds of image-making or creative production are all components of visuality. Not least among them is the wish to intervene and change what is thought about what is seen. When Joyce writes, "Ineluctable modality of the visible: at least that if no more, thought through my eyes" (1922, p. 45), he captures an elusive interplay between thinking and seeing, which also extends into action.

Qualities of visuality used consciously by the author during the Moon Vehicle project include creating memorable experiences that although short lived endured in part through their visual impact. 'Moon Stories', which was held on the rooftop of the Visvesvaraya Industrial and Technological Museum at dusk as the full moon was rising, was one such event that was designed with a compelling visuality. The full Moon was projected onto the flat rooftop via a telescope, digital camera and projector in such a way that the audience/participants could sit around the circle of the Moon image and exchange vernacular, traditional, scientific and other stories they recalled about the Moon. This use of visual elements as part of a semi-performative, participative event was repeated in other activities of Moon Vehicle (see Panel 9, Chapter 4). The visual alacrity of such events, it is argued, was an interventionist strategy that permeated both the lived-world and imaginaries.

In a study of resistant acts of looking, visual culture theorist Nicholas Mirzoeff (2011) recognises how subalterns generate their own forms of visuality in order to alter their position. He gives this process the term 'countervisuality'. The term visuality is used by Mirzoeff to indicate an authoritative regime of seeing and looking. He considers a genealogy of extreme examples of such regimes of looking that include slave plantations and the more recent military regimes of the United States in which the invisibility of extraordinary extradition and the regulation of the sight of prisoners in the Guantanamo Bay detention camp are examples of the connection between seeing and liberties. His examples draw on Foucault's discussion of the Panopticon in *Discipline and Punish* (1977) and of personal liberty (Foucault, 1987). Mirzoeff also recalls the proposition developed by Dipesh Chakrabarty of History 1 and 2s (2000a). He indicates how episodes of countervisuality constantly interrupt, resist or destroy more authoritative regimes of looking. The model of History 1 and 2s proposed by Dipesh Chakrabarty is translated by Mirzoeff into Visuality 1 and 2, in which Visuality 1 "creates a picture of order" but has an authority constantly reshaped by Visuality 2, or "countervisuality" (2011, pp. 22-24).

One of the examples used by Mirzoeff in *The Right to Look* is a woman called Sojourner Truth who after her emancipation from slavery in the United States travelled the country giving addresses on rights to freedom. Truth constantly walked the country living through her faith and on the kindness of those she encountered (Truth, 1850). Mirzoeff calls attention to her mobility and also her use of photographic reproduction to spread her message (2011, pp. 146-150). Her grasp of the workings of the visual, through technology is conveyed in an image produced by Truth as an element in her campaign. The postcard sized black and white photograph is of her seated in a fairly usual Victorian pose next to a small table holding her needlework. The photograph carries the caption "I Sell the Shadow to Support the Substance. Sojourner Truth." The "shadow" is both an illusion to herself as a Black person, a metaphor also used by W.E.B. Du Bois (1903), as well as a reference to the imaging through light and shadow of photography. It is a far more complex image than this because Truth looks out directly at the viewer mobilising and multiplying her right to look, through her deployment of a new media technology. Even her own name is part of her method, chosen by herself as another act of self-determination following her emancipation from slavery and the photograph itself is used in another double-function, as a commodity sold to support her campaign. Through her mobility, her charismatic personality and her use of imagery, it is as if she has multiplied herself, or distributed her presence like a film across populations who come to know of her and her message. Of this operation of multiplication and mobilisation Mirzoeff writes:

> Truth was constantly nomadic, always in pursuit of emancipation, generating a complex, even chaotic visuality out of the stale clichés of her time. As Daphne Brooks has put it: "From the darkness of the void which she creates, surplus Truths are put into play". (Mirzoeff, 2011, p. 150)

Those "surplus Truths" which Daphne Brooks proposes in her book *Bodies in Dissent* (2006) are produced by Truth's creative and courageous performance of her "self", a production that displays an alacrity with the visual. Truth magnifies her presence via the workings of the imaginary that brings duration to her sporadic and brief appearances. In Brook's writing on performances of racial heterogeneity, such mobility combined with visual alacrity brought duration in the memory of the viewer and constitutes the agency of the "performative". Brooks traces how multiplication and mobilisation through the imaginary were tools of resistance deployed through a lineage of actions in which subalterns of many varieties sought a reshaping of habitual, dominating, normalised, unnoticed and otherwise unquestioned social behaviours and legalities, which in the case of her study are associated with narrow definitions of race. Brooks writes:

> Wedding social estrangement with aesthetic experimentalism and political marginalisation with cultural innovation, these resourceful cultural workers envisioned a way to transform the uncertainties of (black) self-knowledge directly into literal and figurative acts of self-affirmation. (Brooks, 2006, p. 3)

Brooks makes the strong point that what these performers achieved was the creation through performance of heterogeneous identities in order, as a first step, to illustrate and produce in the imaginary, a consciousness of the existence of a wider field than was currently being imagined.

A strong link can be made here with the modalities of the visual used in the course of the Moon Vehicle project. In the Moon Vehicle project there was a deliberate attempt to show what the range of stakeholders in spacefaring looked like and thought in order to dislodge presumptions that spacefaring was only for those in scientific institutions, for instance. Through the illustration of subaltern participation produced through semi-performative events, performances, the production of drawings, objects and through being witnessed on site, within the perimeter fences of the space agency, the imagined identities of who it was who could be considered a recipient, participant and a producer of space exploration were arguably widened. A part of what was at stake in this process could be considered as the rights to look coupled with the right to author one's own experience or one's own version of events. Within the limitations to such acts of authorship presented through the processes of seeing Chandrayaan described in Chapter 4, an affinity can be found with the kind of visual alacrity displayed in comparable contexts, such as illustrated by the story of Sojourner Truth and proposed in Brook's explication of the performance of heterogeneity.

A certain dynamics of seeing and being seen is given in the accounts of Sojourner Truth which includes an afterimage or duration of visuality. That afterimage, or duration, or memory of something seen is due in large part to the imaginative nature of the encounter itself. The management of the effects of visual encounters requires a certain ability or alacrity with modalities of the visual. That alacrity is highly dependent on the seamless elision of imaginaries with what is seen and thought. What is seen is dependent on light and light has significant properties in relation to space technology.

Light

The visual properties of spacefaring become foregrounded in many ways by taking an artistic approach. This is particularly so because there are unusual properties at work in space beyond the interferences of atmosphere that impress deeply on the qualities of imaginaries. There is a stark image quality to things in space, hit directly by the Sun's rays, without diffusion of the light, creating black undifferentiated shadows that is altogether unlike the aerial haze of objects on Earth, but similar in some ways to the cinematic image, or the effect of flood lights– light effects that are artificially constructed to attract the spectatorship of audiences. Added to this, the backdrop of black, empty space has given the activities of spacefaring, even as mental images, a graphic boldness. The surrounding black space could be compared to the technique in graphic design of using 'white space', or empty space on a printed page, to give visual and conceptual weight to a design. With a similar sense of design the backdrop of outer space has been exploited, albeit subconsciously, for a similar graphic quality in that the visual focus afforded to activities that take place in outer space comes about in part because of the powerful visual effect of the almost blank backdrop and the quality of undiffused light. Outer space possesses an alluring visuality that is perhaps only enhanced by the difficulty in actual seeing. Without actual seeing these powerful images of spacefaring activities remain as imaginary constructions aided by many kinds of mediated imagery such as from astronomy and science fiction. Through such mediations, spacefaring is constantly associated with what is beyond the atmosphere, at the expense of what is within the atmosphere.

This space borne imaginary and its association with the political uses of space activities can be evidenced in the research of international relations scholar Michael Sheehan (2007). Sheehan repeatedly correlates the visible impact of space activities with international politics. His analysis of the influence on international politics of spacefaring activities depends to a large extent on the imaginary of spacefaring activities and the symbolic as well as inferred meaning (such as inferring ballistic capability) accompanying the material technology. For this to happen effectively in the way Sheehan attests that it does, that persistent imaginary needs to be strong and an element of that strength can be linked not only to the level of endeavour encapsulated by space technologies but to the visual properties of spacefaring within its natural amphitheatre – the backdrop of outer space. Sheehan does not advance an analysis of the visual properties of spacefaring in his study but he does make continued reference to the image of spacefaring, for instance he writes of the "visible measurement of power" (2007, p. 10) or "the image we have of the extra-terrestrial realm" (2007, p. 5) such that a determining place for a visual imaginary of spacefaring can be inferred.

Space technologies are only ever partially seen but their less visible parts are arguably as potent. In the writing of human geographer and anthropologist Tim Ingold, he offers insights into the merging of the seen with the unseen that includes a particular role artists have played in revealing such connections. In the conclusion to an article addressing weather, the experience of light and perception, 'The eye of the storm: Visual perception and the weather', he writes, "Painters know this. They know that to paint what is conveniently called a 'landscape' is to paint both earth and sky, and that earth and sky blend in the perception of a world in continuous formation" (Ingold, 2006, p. 104). Seeing space technologies requires an ability to recognise how the loss of a mediating atmosphere interrupts and transforms this technology.

Through Ingold's reflections on how light is experienced, correspondences can be made between light, ways of thinking and the painter's or artist's ability to discern and foreground the mediations of light, imaginaries and intersubjectivities. The main point of Ingold's article is that light is experienced as landscape through the medium of weather. From this he proposes that understanding the mediation of weather helps another problem which is the tendency to think of light as what is seen and hence as outside of us. By accounting for mediation of weather, light can be understood as a property that flows through and inside us, rather than a property that reveals surfaces. Imagination is then not a reproduction of what is seen outside brought inside the mind by cognitive processes, as imagination has been conceptualised since Descartes. Ingold argues that the light that surrounds us is seamless with the light of imagination because light flows through us – there is no separation.

He compares light to sound which is more easily thought of as coming inside the body and being immersive, and refers to the habitual wrong-thinking that, "Inside the head, it is noisy but dark" (Ingold, 2005, p. 98). In this way Ingold's insights relate to observations within this thesis of spacefaring and imaginaries of outer space, which are habitually posited as outside of the self and thereby away from the granularities of intimate experience. By paying attention to the way light renders landscape a dynamically changing substance and how light as experience brings what is outside, into the person, Ingold reveals certain philosophical barriers to the merging of sight and imagination that have become habits of mind.

Ingold indicates that the science of optics may have encouraged a way of thinking about what is outside the person as going through a process of translation via the imagination to something that is inside, "It is left to vision to reconstruct, on the inside, a picture of what the world is like on the outside" (Ingold, 2005, p. 98), he writes. But sight, like sound, is he contends a phenomenon that is already inside us. Using the weather as an overlooked component of landscape and of experience, Ingold draws back to the comingling of sight, experience and visual imaginary, in a way, that as indicated at the outset of the section is usually better demonstrated through literary prose than analytically in academic papers. Nonetheless what Ingold expounds in this article and through his research in general, helps to remind that what we see is not separate from us: What we face is also absorbed, thus comingling our 'selves' with the world through the process of seeing. The absorption and interpretation present in the first-person viewpoint is evidenced in the acts of drawing and writing which physically articulate such a positions in the world. Plays of light can be noticed to enhance or diminish imaginaries of what and who spacefaring is thought to be for. It is in discerning such correspondences and mediations that Ingold credits the painter who has the ability to "paint both earth and sky" and, moreover, value the continuities of perception that include the viewer in the picture they paint through the act of authorship.

Some of the light that falls on the constructions of space technology strikes directly from the sun creating starkly illuminated architectures. Some of the constructions of space technology are located in the fuzzy light of Earth. Qualities of light viewed directly or held in imaginaries direct attention more easily to the alluring structures in outer space. When the cultural archaeologist Alice Gorman explores less stark ground-located effects of spacefaring, she foregrounds the lives of real people affected by space installations. Her studies of space technologies through the material culture of artefacts are suffuse with a grounded Earth-bound light in which edges are not stark, but merge and become almost indiscernible. Her study of the

Woomera launch site in Australia addresses social injustices arising when local inhabitants of the landscape – the Aboriginal communities – are obscured from the purview of the visiting scientists testing rockets at the site. She comments on the ambivalence with which locality is acknowledged and obscured in the terms of the space agency, drawing the dry conclusion that spacefaring, "transcends local interests" (2007, p. 165) and noting with some irony how, "In the process, [of spacefaring] Indigenous and other local populations face a range of impacts from dispossession to recruitment" (2007, p. 155). The benefits that the space agency gives to local inhabitants are not necessarily ones of their asking. Gorman shows that the power to acknowledge or not acknowledge cultural difference lay firmly with the visiting space scientists, for even as the scientists denied the Aboriginal presence, she writes that, "half-caste girls were employed as domestic staff" (2009, p. 137-8). This asymmetry in negotiations at the borders of spacefaring on the ground is given demonstrable form by the organisation of protests by local people. Staged from without, the protests draw attention to the diffused purposes of spacefaring, and, to follow Chakrabarty (2000a) an intermingling with antecedents not a part of its logic, but nonetheless implicated by and within the affective space of its enterprises.

Gorman's studies of rocket launch sites in landscapes such as the desert at Woomera, Australia and tropical forests in Kourou, French Guiana call attention to the ways local inhabitants living within these landscapes become subalterns in the enterprises of spacefaring at the moment they become neighbours of space agencies.[163] The incidental light effects of these sites seem to echo, or provide a sympathetic background to a problem of subalternism within spacefaring. The stark figure-ground differentiation afforded activities in outer space, by the indisputable clarity of black negative space, does not hold true for the study of space installations on the ground. Foreground cannot so easily be separated from background in the softer light on Earth. While calling attention to the visual properties of light and landscape are not a concern within Gorman's work, a correlation can be made between the Earthlight latent in her studies and the focus she brings to the people at the blurred edges of spacefaring enterprises. It is as if the space

[163] Peter Redfield (1996; 2000; 2002) has also made a substantial study of the cultural geography of the launch site at Kourou. There are also correspondences to be made with Itty Abraham's essay *Postcolonial Science, Big Science and Landscape* (2000).

installation is imagined from within as having the sharply defined edges of space technologies located in the pristine light of outer space, easily separated from their surroundings.

A similar pattern of asymmetrical negotiations at the borders of the space agency was in evidence at Byalalu village to the south of Bengaluru, which is the site of the Indian Deep Space Network visited during the Moon Vehicle project. Here, engineers at times required police escorts to enter the site because of the protests of people from the village. The space agency built a new road to serve the site that is mentioned sometimes as one of the benefits to the village of the new space installation.[164] Local people are employed for construction, catering and security work. In the process of the construction of the Deep Space Network site a family temple was enclosed within the perimeter fence and became no longer available to the family, instead being used by the ISRO security guards. Such blind spots can be understood as characteristics of the visuality of space technologies that structure relations with social domains. The allure of spacefaring becomes somewhat dangerously aligned with a rejection of the complexities of lived experience found in the fuzzy light of Earth.

The technographic picture

The outward demonstration of heterogeneous identities and mandates to look can be foregrounded through an artistic approach. When the domains of inner and outer are understood to be part of the same continuum, the interconnections between what is seen and imagined can more consciously affect the way technologies are thought about. What is suggested through this argument is that the artistic approach has the potential to acknowledge such a continuum, which can be missed by other approaches. The through-flow of imaginaries of space technologies is articulated by extreme differences in properties of light that like certain architectures exacerbate

[164] The cultural geographer Peter Redfield writes in his book *Space and the Tropics* (2000) about protests around to the construction of a new road by the space agency in connection to imperialist agendas imposed on local inhabitants.

a separation of occupants from their wider environment. With such correspondences in mind, the technography presented in the first part of this thesis can be revisited.

The technography of the spacecraft Chandrayaan presented across Chapters 2-4 crossed domains of the space agency workplace, a public sphere of mediated commentary and representations of the spacecraft as well as an artist-led interventionist project. Links and mergings were identified between these domains amongst persons, imagery, artefacts, sites and imaginaries. These mergings rendered the separation of these domains into three chapters unrepresentative of the spirit with which they were actually encountered (as described closely through the real-life experience presented in Chapter 4 of the Moon Vehicle project). This unordered, real-life, phenomenological experience has much in common with the crossing of domains that the social anthropologist Bruno Latour has sought to reinstate an awareness of in the discourses of the social sciences relating to science and technology. Such unordered, contradictory and ambiguous mergings of persons, things, organisations and their processes are, he reminds, the primary conditions of contemporary experience. But somehow it is not the connections but the separations which are more often recognised, "That a delicate shuttle should have woven together the heavens, industry, texts, souls and moral law - this remains uncanny, unthinkable, unseemly" (1993, p. 5), writes Latour. Separation and purity are symptoms of the idea of being modern in his view and these qualities are reinforced in the practices and organisation of science and technology.

In *We Have Never Been Modern* (1993) Latour sets out a philosophical approach to the networks of affect and effect that are more generally unacknowledged in the organisation of science and technology. Latour indicates that the kinds of problems followed by him and colleagues are not only studies of the material processes of science and technology, but also social studies, studies of discourse and studies of politics (Latour, 1993, pp. 3-4). The research that Latour refers to demonstrate that modern life is not as contained and segregated as the modern organisational structures of factories and institutions would seem to suggest. The shuttles weaving between things and people, social relations and places, between the domains of state, institution and elsewhere, may be less visible than the architectures of separation but nonetheless these networks of connectivity and organic interplay are simply the nature of all things. While fundamental to the idea of being moderns is that of separating and purifying (such as culture from nature, technological from human) when Latour asserts that 'we have never been modern', he breaks this illusionary spell and draws attention back to the fluidity of affective spaces and of our lived experiences characterised not by purities or separations but by hybrids. Latour notes that the anthropologist's text has been a form that has always addressed such fluidity and hybridisation well and that this approach to describing the interrelations between "the distribution of powers among human beings, gods, and nonhumans; the procedures of reaching agreements; the connections between religion and power; ancestors; cosmology; property rights; plant and animal taxonomies" (1993, p. 14), lends itself to seeing the fullest "constitution" of things – as Latour terms these networked states. In the same spirit, as has been indicated through the course of Chapters 2-4, the technography of Chandrayaan can be imagined as always collapsing into and through itself, of being impure and contaminated by the whole of its affective space, an affective space at some points knowable, visible, discernable and at others remote, invisible, ineffable, behaving as a kind of dark matter, unseen, but nonetheless driving effects alongside the more observable infrastructure.

The technography therefore needs to be reconstituted or re-imagined as integrated. In this state of imagined integration, the technography suggests something more than the network, because in the roots of the word is the suggestion of a graphic or a picturing. The technography of the spacecraft presented in this thesis provides what could be thought of as a 'technographic picture' of the spacecraft in its multiple domains as material entity and affective space. This technographic picture suggests another way in to realising the natural state of connectivity and the interrelation of things. Furthermore, the way that the spacecraft Chandrayaan has been approached in this thesis has been primarily through an artistic lens, in that the author negotiated access in her capacity as an artist and her access was also limited by this capacity. One of the advantages of this artistic approach is that the shuttling and interweaving of domains can be readily thought of in visual terms. In accessing the problem through an artistic lens the kinds of weaving and shuttling can be thought through with an awareness of their optics as arrangements of persons, artefacts and situations in correspondence with each other but without full visibility of each other. To think in this way requires a kind of thinking that uses visual imagination to picture the technography as an imaginary of spaces, landscapes and components in dynamic and shifting relations.

The proposition by Dipesh Chakrabarty presented in the previous chapter of History 1 and 2s entwined in ongoing negotiations and interruptions provided a staging towards this way of thinking. This staging helped to indicate that positions of subalternism were not held by specific groups such as non-scientists, or specific persons, but were far more mixed up. Instead of thinking of communities meeting at their edges, almost as if arranged in adjacent fields, the idea of History 1 and 2s always coexisting helps in building a more nuanced interpretation of how space agencies and publics interact and coexist. Like the anthropologist's text, the artistic approach can be revealing of interweaving that is not always self-evident. In a slightly different way to the text though, artistic practice has the potential to work back into the fabric of lived experience a consciousness or greater awareness of the structure such interweaving takes.

When what can be seen is only ever partial, when, in the case of large technological systems such as space technology, the whole has to be imagined from the partial glimpse, such as an image of a rocket launch or the visitor's centre of a space agency, then the quality of what can be imagined or pictured takes on a important role in relation to the use and subsequent shaping of the technology. The spacecraft is an ambivalent entity, difficult to see, because to an extent it takes on a slightly different identity from any one vantage point. The graphic or visual dimension of the technography includes the expansive, affective realm that can be pictured in the mind or imagined. The imaging of the technography as a technographic picture – in all its richness or otherwise – happens in the imagination. It encompasses persons, places, workplaces, activities, with their groupings, commonalities, mergings and dissonances encountered in fragmentary and dislocated ways that can be brought together and pictured using the faculty of imagination.[165]

The technography presented is a cacophony of propositions, of encounters, of positions and intentionalities, of pragmatics, politics, motivations, tactics, readings, misreadings and re-readings. It consists of discourses that demonstrate connections, creative actions that demonstrate fault lines and politics that demonstrate opportunity. Latour's insight that 'we have never been modern' further substantiates that the life-world of technologies always consists of such a cacophony of connections. However, the translation of the technography to a technographic picture offered in this thesis opens and extends the interpretation of technology in distinctive ways. This is the key original contribution the thesis makes. It argues that taking an artistic approach brings a foregrounding of viewpoint and experience allowing for elusive problematics to become visible and at the same time acknowledging how the flow of what is viewed and experienced is inseparable from the imaginative and intellectual structure given to such problems. A technographic picture carries an implicit relation to the visual imaginary. The painter or artist is familiar with this connection and familiar with finding ways to demonstrate through the struggles involved in the production of artworks that such flow between what is

[165] The points raised earlier in relation to the research of Alice Gorman on the cultural landscape of space has a great deal of correspondence with my explication in this chapter of the value of the technographic picture as a tool for addressing the conceptual/cultural social divides produced by the enterprises of spacefaring. Her framework is the cultural landscape of space technology, “A cultural landscape approach offers a framework for studying the relationship between places, associations and material culture” (2005b, p. 88). She uses the idea of "associations" (much as I have used the notion of 'imaginaries'), to denote immaterial values. The technographic picture, as I have built the a concept through the thesis, complements Gorman's cultural landscape approach that emphasises also a need to shift away from the problematic assertion of 'humanity' and a materialst conception of space technology and seems to suggest instead focusing on a landscape of values. Her framework builds on insights from cultural heritage management in Australia (she draws on recommendations in The Burra Charter (1999) as a seminal document that gives high priority to cultural values and associations of landscapes). In my analysis of her research I comment on a correspondence I find between her ability to see the effects of space technology on marginalised neighbours of the space agency and the fuzzy Earth-light (as opposed to the stark light of outer space) that seems to flood her papers about space technology. The technographic picture that I develop in this chapter contributes an important dimension to re-imagining how space technologies affect social domains, for one, because it allows for the experiential quality of light to be factored into analytical critique. The proposition of the technographic picture would also complement accounts of space technology by the cultural geographer Peter Redfield (1996; 2000; 2002) who has written about the consequences for local populations of the ESA launch site at Kourou in French Guiana and also the research into affective spaces of space technologies by cultural theorist Lisa Parks (2005; 2010. The work of all three could be read for the 'technographic picturing' it affords in that there are affinities with my own study. However, the proposition outlined here is that any technography affords a 'picturing' and it is here in the comparison of 'pictures' that new kinds of analytical understandings of the way space technologies are thought about could begin to emerge.

inside and outside of us – a mediation that the objects which surround us appear to deny – is part of the nature of direct experience. By overlaying the contribution that artistic practice can make to the interpretation of the merging of the social and technological certain difficulties in seeing space technology become more manageable.

A subaltern aesthetic

As part of the re-imagining of space technology from an artistic perspective argued for in this thesis is the recognition of an aesthetic seam. The aesthetic seam bound to spacefaring enterprises is argued here to be subaltern because it is suppressed to a large extent within the organisational structures of spacefaring. This aesthetic seam can in part be brokered and distributed through artistic engagements. It becomes visible in the friction of activity and the direct experience of engaging in creative practices that go against the grain of the practices of the epistemic communities from which space technology emerges. The friction or interruption augurs a new interpretive capability. In the aesthetic framework uncertainty and ambivalence are ruptures or fault lines that provide an immaterial culture from which to build pictures of the motivations and circumstances that bring them into being. From the framework of the aesthetic encounter qualities like uncertainty and friction provide interpretive pathways. They are not failings or inadequacies as they might appear from the political, scientific or technical perspective.

A subaltern aesthetic permeates spacefaring as a surplus to the aestheticising by state. As spacecraft are launched owners become differentiated from non-owners. By authoring the affective space of space technologies through imagery, commentary or films nation states can harness technological apparatuses for political effect. Yet even as this happens, supplementary spaces appear for the authoring of "History 2s" – counter-histories, imaginaries and visualities – from which radical agencies emerge. If artistic practices have shown the capability to access radical spaces of agency from which to re-imagine space technology, these openings in turn generate further supplementary spaces available for other opportunistic interventions. A subaltern aesthetic, accessed through the artist-led activities of the Moon Vehicle project was made avaliable not only to artists, educators, children and students, but also to ISRO employees and astronomers, who opportunistically took advantage of the dialogues and activities generated by the project and normally disallowed by their institutions.

The purposes of space technologies are complicated by contradictions from which the subaltern aesthetic generates a productive critique. It is the structural ambivalence of space technologies that attract artistic sensibilities. The contradictions invite critique, more so perhaps when the contradictions are so compelling: When the gesture of interplanetary exploration is so starkly disconnected from aesthetic, reflexive and critical frameworks of discourse, everyday language and expression because of the disciplinary separation and organisational separation of science and technology. It is the subaltern experience of space technologies that opens up this aesthetic seam from which radical agencies emerge and contributes an important dimension to re-imagining how space technologies affect social domains. The final section offers a framework or modality through which to conceptualise such a re-imagining.

A proposition for the analysis of the technographic picture

The transdisciplinary moves made in this thesis produce a new modality in which qualities of visuality coax out the imaginary and real world interweavings that constitute technographies. What is proposed next is a further move that would substantiate this insight. It is a suggestion for how space technologies (and other large-scale technologies) could be opened to a new analytical framework derived from the transdisciplinary moves that have been made in this thesis. This proposition draws specifically on analyses by two art critics and as such is offered as a speculative idea for future work. There is in the analyses of these critics the articulation of processes that foreground intersubjectivities, which occur through art making.

The critic Rosalind Krauss based in the United States was active and influential particularly during the 1980's, writing seminal pieces that commented on current shifts in art practices that she observed. In an essay written in 1971, 'The Problems of Criticism', she writes about art practice being something that shifts as circumstances in the world require other solutions. Here she is writing about a shift in what is being represented in the pictorial space of recent painting. She suggests that the shift observed is a document of a change in conditions and she proposes a way to interpret artworks as documents or symptoms:

> I see it [pictorial space] as a function of conditions external to art itself which call it into being and which determine its meaning by defining how it will be used. Should those conditions change, so will it change – not just quantitatively but qualitatively. At the present, we have reason to think that painters themselves are reacting to a change in objective conditions and it is to the symptoms of that reaction that I want to turn. (Krauss, 1971, p. 68)

Krauss here notices the diagnostic function of art, its ability to document what is happening in the world through a pivotal activity of reflection and immersion in the world. In particular she sought to look beyond what artists appeared to be doing or depicting, to underlying structures. While pictures may help bring clarity, as in the way illustrations provide helpful guides to text description, the making of pictures is fraught with the intellectual struggle of thinking through the image. This struggle can be evidenced through the work of painters that traces processes of depiction in which perception, objects, spaces, together with the passions and uncertainties of lived experience collide and collude in the thinking through of picture-making. The merging together of what is seen and unseen evidenced through the struggles of picture-making has a bearing on the ways a technographic picture might be imagined or depicted mentally and itself used as a guide.

An article by the friend of Rosalnd Krauss and fellow art critic Leo Steinberg called 'Resisting Cézanne: Picasso's "Three Women"' (1978) tenaciously follows the painted marks made by the artist Picasso and their evocation of what is seen and experienced.[166] In this article Steinberg

[166] While for the purpose of the chapter I limit the discussion to this one paper by Steinberg, my familiarity with Steinberg's thinking and analysis of artworks come from my experience of being taught by him in 1989 when I studied at the University of Pennsylvania, where he was Benjamin Franklin Professor of the History of Art. What I remember from that semester of weekly seminars is Steinberg's insistence on looking at the paintings and not at commentary for interpretations. This proposition for

argues for a depth of struggle within the work of Picasso, in which an array of resistances to the painter's predecessor Cézanne, as well as influences, form an abundance of hitherto overlooked propositions in a selection of works that are indicative of a transition in style. Briefly, what Steinberg takes issue with is an interpretation that these signs of transition indicate the influence of the older painter Cézanne on the younger painter Picasso's moves towards a cubist style of painting. That reading is too teleological for Steinberg, too neat a history, and instead Steinberg looks very closely at a selection of less discussed drawings and paintings by Picasso. He reads these works by moving as much as he can into the frame of reference that the paintings themselves and their struggles provide evidence for. The faceted planes distinctive in Cézanne's work are evident also in the work of Picasso. These planes in the work of Cézanne seem to indicate in their sharper edges spatial intervals between things and in their blurred edges the mergings and connections that are as much visually present in the landscape, in the form of continuities of colour, as they are experientially and emotionally present as continuities of value and meaning. These edges and mergings draw attention to the lack of fixity in the daily, even moment by moment, appearance of landscape, which in Cézanne's renderings could be thought of as depicting an experience of light and of life itself.

The mergings of planes innovated by Cézanne have been termed *passage*.[167] Elsewhere Steinberg has indicated that *passage* occurs as a compositional device in more figurative early work by Picasso, such as *The Family of Saltimbanques* (National Gallery of Art, Washington, 1905).[168] In this work, interruptions to the outlines of figures seem to indicate a psychological dimension of the acrobats' uneasy, peripheral relation to society, rather than an oversight in the drawing. A key aspect of Steinberg's contribution to the study of Picasso's work has been to follow the intelligence of marks often overlooked or interpreted as random by other critics. By doing this, Steinberg forces a consideration of the intellect of these works by paying close

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analysing the technographic picture, draws on Steinberg's analyses which he presented in the seminars I attended and are available also in his writing.

[167] Steinberg quotes the critic William Rubin in this article in which he notes that Picasso is working, "within a consistent system of passage" (Steinberg, 1978, p. 116, quote from Rubin not cited)

[168] Steinberg spoke of passage in relation to *The Family of Saltimbanques* painting in his seminar series that I attended at the Universty of Pennsylvania in 1989.

attention to the dynamic frame of reference of the paintings themselves. His synthesis thereby suggests a complex play of both influence and resistance:

> ...Picasso's problem in 1907-08 was not merely to assimilate what Cézanne had to teach, but how to resist him. There was a conflict, and this conflict seems to me crystallized both in the faceted surface and the dire emotional tone of *Three Women*. (Steinberg, 1978, p. 116)

What Steinberg's close analytical method provides is a particularly rich interpretation of interrelations both visual and experiential, with particular emphasis on the emotional – the passions and uncertainties of humans which become imaged throughout the work of Picasso. In their awareness of the interplay of vision, experience, cognition and the person, Steinberg's analyses of the forceful syntheses with which Picasso engaged provide an unusually cogent guide to a comparable set of interlocking planes foregrounded in this thesis. The mergings and conflicts foregrounded through the technographic picture of a spacecraft presented here all relate in some way to forces of personality, passions and intellects. In the final resolution of this thesis is a proposition for an apparatus for keeping in mind – for seeing enfolded with imagining – the fuller picture of interrelations revealed by the technographic picture. For this, Steinberg's elucidation of the painterly struggles of Picasso can provide some guidance with which to draw together the blurrings and mistiness, conflicts and edges present in the experiences of the structurally ambivalent technologies of spacefaring.

As a first step, there is in this essay a vocabulary that gives a method for visualising the array of encounters that have been described through the technography of Chandrayaan. The notion of *passage* describes many kinds of mergings of communities, shared spaces, anxieties and aspirations that were in evidence during the Moon Vehicle project and occur across the affective spaces of spacefaring in general. To this Steinberg adds another term *arris* that he uses in his analyses to denote marks indicative of tensions. The *arris* is the moment of a curve changing from the upward to the downward, for instance in the curve of cheek where this shift in direction lacks the visiblility of an outline or a bone structure, but is vital nonetheless as an indication of opposing forces within forms. Marks that other critics have dismissed as random, Steinberg follows to reveal an intense intellect at work. Form is not separate from but coincident with psyche and is revelatory of an intellect. This is what Steinberg finds when he trusts that the actions of the painter have intention:

> It must be that the psychic content and the chocked surface structure of the painting are somehow coincident; for the coincidence is what one sees – only in thought and theory do these "two" fall apart to become separate considerations. (Steinberg, 1978, p. 121)

What is drawn from this for the purposes of this thesis and the problem it attempts to disentangle is that once the picture can be seen, then its interlockings and incommensurabilities, if trusted as actions made with intention and if followed closely, are revelatory of an intellect. In the terms of this thesis, if the technography (however it is arrived at and artistic practice has been shown to very useful in generating this) is used as a method of generating a technographic picture, that this is a first stage. Then a second stage involves trusting in the intentionality of all elements of the picture presented and using this form (however frailly it is held as an imaginary and structurally insubstantial series of glimpses) as an apparatus from which to infer an intellect.

The process of making visible, outlined in the artistic approach adopted in the Moon Vehicle project and its subsequent analysis through the writing of this thesis, is a first stage from which to then reflect on the generation thereby of a coincident figuration. For Steinberg the figuration of an intellect was an intrinsic part of the painting, if not its primary reason for being. The work of the viewer was then to find and interpret what was being laid open for interpretation by the artist. Steinberg's insistence on searching for the view of the painter through the evidence of the painting has similarities to an anthropological method of interpretation. Recalling Latour's observation that the anthropologist's prose can describe interrelations and intersubjectivity, in a similar way, so can painting. Steinberg's analyses indicates how artistic ways of looking and thinking reach beyond the surface appearance of things. Scientific methods of inquiry also reach beyond the surface appearances of things, but rather than look for the physical origination of phenomena; artistic inquiry locates through an aesthetic register that allows the immaterial dimensions of affect to become visible.

Works of art are a kind of test bed for interpretations but the critical methods of the art critic need not be confined to artworks. Rather what is suggested here is that critical spectatorial work (Mitchell, 1994, pp.3-4) has moved to other compositional arrangements such as found in the materialisations of space technologies. Compositions, to echo Krauss, reflect conditions external to their production and space technologies like artworks are compositions of a sort, reflecting external conditions and subject to such conditions. If the techniques of the art critic are applied to the technography, the writing together of the scientific with the artistic becomes a type of *passage* and the tensions of this writing together, like *arris*.

A technographic picture, made open to interpretation like a painting, allows the immaterial and mutable elements of that picture to have visibility beside the robust materiality of, in this case, space technologies. Moreover, the technographic picture, critically interpreted like a painting allows for agencies with little visibility to push, pull and merge also within a framing in which all elements are trusted to hold meaning. The translation and mediation of space technologies through social domains flow not one way or two ways but permeate inexactly and in unexpected ways. If such interactions are thought of in the same way as Ingold thought of the properties of light as mediated, as flowing through us, inside us, as involuntary processes which we can never stand outside of, then some uses of the technographic picture become apparent. It is apparent that technographies flow through the imagination and cannot do otherwise. The technographic picture of a spacecraft is like a landscape that the mind can move through and to which the insubstantial and mutable nature of imagination lends itself. It is apparent that our viewpoints change without us having to move our eyes. Just as light and landscape are seamless with the dynamics of weather, so our viewpoints and our opinions, disciplinary positions, our attention and our affective states are in a constant state of mediation. If the question of who spacefaring is for is asked by attending to types of experience, authorship and ownership this reading produces an image of the affective space of spacefaring that links distinct communities and persons in unexpected ways. Such links are not readily apparent but can be found through real-world activities and critically devised interactions such as present in artistic practices described in this thesis. The authoring present in acts such as writing or drawing provide a friction by which such qualities, links and connections can be noticed and valued. When such myriad acts of authoring are made visible, the question of the purpose and ownership of spacefaring acquires intimate readings, despite the structural lacuna in the connection of the theatre of space technology to its audience.

Conclusion

This concluding section brings together the discussions of the thesis in relation to its aims, highlighting the significance of the insights reached for other fields of inquiry and for future work. The thesis has responded to questions about spacefaring: Who is it for and what it is for? It has used the ambiguities of spacefaring to open up some problems in the ways space programmes relate to social domains affected by them. It has done this from the viewpoint of an artist in order to foreground how viewpoint itself and the experiential accesses elusive aspects of these questions not available from other disciplinary perspectives. What was opened up through this approach was an affective space of critical reflection, creative participation, tactical resistance and other kinds of inflection available within intimate spaces habitually overlooked in accounts of the purpose of spacefaring.

Insights and implications

Structural ambiguities were found in explanations given by or on behalf of space agencies as to the purpose of spacefaring activities. The affective space of space technologies was found to be unpredictable and complex because the nuanced ways that space technologies can be associated with and used is deftly managed by state and citizens alike. The meanings of space technologies in wider social domains than the space agency sites of production are subject to many kinds of reinterpretation and manipulation. The formational imaginary that spacefaring benefits all humankind is easily dislodged as political rhetoric but the real-world affects of space technologies remain so hard to grasp or identify that the myth of benefit for all people tends to hold. Who space technology was being made for and how it is used is subject like all technologies to interpretive flexibilitiy (Pinch and Bijker, 1987). However, a particular set of tensions arises in the case of space technologies because the opportunity to interact with the technology or to feel involved in the determining decisions leading to space missions are extremely delimited.

A difficulty in ascertaining the uses and affect of space technology was identified and equated with a difficulty in physically seeing the material technology and figuratively seeing its immaterial consequences. By equating a problem in the relations of space technologies and social domains to a difficulty in seeing, the problem was then accessed via properties of viewpoint and experience. Because the imagined viewpoint of the whole Earth from outer space suggests a position can be adopted whereby a total account of the species can be made, there is a tendency to associate spacefaring with a species-level affect. Although it is not difficult to dislodge the idealism of this tendency to think of spacefaring as affecting the whole of humanity (for instance with the realities of the many kinds of self-interest or national-interest found to be guiding commercial or military interest in spaceflight) the allure of such an imaginary remains strong. The imaginary viewpoint of seeing the whole Earth from space was used in this thesis as an entrance point through which to understand patterns in the relations of space technologies to social domains. By inverting the Archimedean viewpoint of seeing the Earth from space and focusing instead on the first-person experiential viewpoint, a new set of insights were reached about the nature of the affective space of space technologies and the methods by which the intimate and elusive intersubjectivity produced by space technology could be evidenced. Key aspects of the insights gained concern firstly the agency to intervene into imaginaries that is offered through the artistic approach. Secondly that there is a symmetrical correspondence between the subalternism of scientist-makers within their own projects and the sophistication of a less proximal citizenry's tactical uses of space technology.

In order to reach these insights, the artist-led project Moon Vehicle that initially gave rise to the questions of the thesis was situated within the context of the state and scientific imperatives which at the time of the practice and from the perspective of its activities was not easy to grasp. Placed into this wider context, the actions and motivations of the project became understandable, almost predictable, as perhaps the only possible form of critical intervention that citizens could initiate in response to a space mission. At the time the motivations for the artist-led intervention appeared to come from anxieties and frustration over the missed opportunity of the ISRO space agency located in Bengaluru to engage their missions with diverse social groups of the city. It was easy to sense the vulnerability of the cultural and artistic concerns of the project next to the far more established aims of the space agency organisation and to consider the role of the artist-led project as ultimately negligible and having little effect. The closeness of scientific and technological projects to the concerns of the state that becomes more palpable when a spacecraft is launched into space reinforces the sense of the vulnerability of cultural and artistic concerns in relation to the state. The concerns of the state become manifested in education programmes that value the technical and scientific over the creative and experiential.

Understood within the theoretical, scientific and state contexts presented in this thesis, the actions and motivations of the Moon Vehicle project took on a robust position. The nuanced resistances of the project recalled a genealogy of resistances ever-present in responses to space technology. The secondary example of the SITE project indicated comparable circumstances in which critical resistances to large-scale space technology were overlooked. The supplementary example that drew on methods of subaltern historiography furthermore indicated that the space of experience and the modality of viewpoint had been used elsewhere as significant heuristics for recognising the charged interactions constantly interrupting habitual or dominant narratives.

The structural ambivalence of spacefaring gives rise to critical questioning of its purpose and ownership. This is inevitable. The establishment of a societal space programme in India can be understood as a critique of the United States space programme's deviation from the ostensible goal announced by Kennedy to serve humanity. What was emphasised in this thesis was that it was not just an original or alternative type of space programme, as the Indian space programme has tended to be viewed, but rather it was actively critical of the purpose of space technology applications and linked to the strong stance of non-alignment by India during the Cold War. In the current climate of national space missions there is little sign of criticality or re-thinking of the types of activities that should happen in space. Instead space missions appear imitative with similar goals of reaching the Moon, Mars and an asteroid found repeated in the agendas of the national space programmes of China, India, the United States, Japan and the European Space Agency. A space of criticality that at one time could be found to have existed prominently within the organisational structure of the Indian space programme, appears to have been lost. The move of the Indian space programme to launch the spacecraft Chandrayaan to the Moon does not indicate a distinct ideological path. Nonetheless in the detail of its instrumentation it is found to be innovative and scientifically to offer a path to the incremental building of knowledge that is the necessary method by which new scientific knowledge is reached. Seen from one viewpoint Chandrayaan can appear to renege on the societal ideology on which the Indian space programme was founded. Seen from another viewpoint Chandrayaan continues the high quality scientific investigations of the wider environment of planet Earth out of which the space programme originally emerged. The co-existence of such kinds of ambivalences produces an ongoing instability in the relation of space technology to social domains.

What is of concern is not so much the structural ambivalence of spacefaring but the dislodged place of criticality that has emerged in the current climate. The thesis finds however that criticality has not disappeared either from the organisation of space programmes or elsewhere, it simply manifests within a more intimate zone of experience. A sense of being ill at ease with the manifest production of space technology may not be apparent from the large view of operations and missions. As shown in this thesis though the sense of being uncomfortable with the ambivalent purposes of spacefaring becomes very apparent at a close-to range where anxieties were found to manifest in the interventions and actions of small groups. When experience and viewpoint are foregrounded as sites of meaning making with certain agencies to modulate technological form then the picturing of large-scale space technology alters. The vulnerabilities and fragility of intimate spaces of encounter also become foregrounded and the make-up of existing imaginaries based on imagery of technologies in space become open to question and available for re-thinking.

The cascade move made in this thesis from the critical intervention of the Indian space agency to the critical intervention of a small-scale, artist-led project can be read as part of a genealogy of critical resistance. Viewpoint and experience are heuristic devices that allow fragile evidence of critical resistance to be foregrounded. This use of viewpoint and experience to foreground critical resistances within a technography of space technology is a key contribution of this thesis. The thesis method and analytical approach – its artistic approach and artist-led viewpoint – opens up a friction within the production of space technology that can be evaluated. The friction becomes apparent only in slight spaces that have been variously described in the thesis as an unacknowledged seam of experience (Chapter 2), the space of encounter between persons, the signature within a drawing of remix and interpretation (Chapter 4) or within a thin space of agency between the viewer and the screen (Chapter 5). Such slight spaces of experience, encounter and signature are more readily accessed through artistic approaches that are sensitive to the properties of viewpoint and experience. When these slight spaces are considered through the artistic lens as authorial spaces in which agencies of the viewer can be materialised, articulated, performed and otherwise made evident then aspects of the immaterial, affective realm of space technologies become available for consideration.

Within the proximal zone of spacecraft production is a complex symbiosis of experiences between the spacecraft and mission teams. This hard-edged, remotely located technology belies the subtlety of the human interactions that are inseparable from its materialisation. Yet coterminous to such direct involvement in space technology production, the technology also comes to be adopted, reclaimed and infused with meaning far beyond the site of its production. This happens most evidently in the adoption of space technologies into nation-state iconographies in which they become political symbols. In this transference to political symbol the value and determining influence of what can be called an imaginary of space technology is plainly evident. The power to influence national imaginaries of spacefaring, which is reliant on access to public-facing media, renders those without influence as subalterns. None of the relations that produce subalternism are fixed however. A sense of being a subaltern in relation to the production of space technology produces both anxiety and the motivation to redress a cognitive injustice. Anxieties have been shown to motivate critical reflection and action and furthermore to reveal a subaltern aesthetic to space technology from which radical agencies emerge.

The thesis has also shown that critical reflection and action is not delineated along obvious lines such as scientist/non-scientist. The bonds that formed between those working inside and outside science and technology institutions during the course of the Moon Vehicle project indicate subtle and complex sharing of action and critical reflection. The agency to act was often displaced from those working under contract within institutions, employees restricted in many ways from overt action or free speech, to the relatively de-institutionalised cultural workers. The observation, participation and motivations of the author of this thesis in the processes of critical reflection and action described, indicate the pivotal role of opportunity, often fleeting, in which authorial agency can be manifested. Authorial agency exists as a kind of third space produced in the intersection of viewpoint and experience. It is aligned with the modalities of knowledge production used in artistic approaches. From this the recent trend for artistic interventions into spacefaring should be understood as an approximate solution to a problem that is still not well defined. Artistic intervention can be considered as having an important diagnostic function. A part of the contribution of this thesis has been to better define the use of some current practices of artists and other cultural workers as heuristic devices for recognising conditions of relations to space technologies.

Addressing limitations

The realm of publics and wider humanity is in the terms of this thesis limited empirically to the observations available through the artist-led project. In that sense it is arguably limited in its scope. The Moon Vehicle project could be seen as an exceptional case because the circumstances by which the Moon Vehicle project came about were in many ways unique and unrepeatable. However projects like Moon Vehicle have been repeated along broadly similar lines elsewhere. Groups without access to space technology have formed with many similarities to Moon Vehicle and used creative actions to redefine the terms of reference of space technologies and technologists as well as challenge assumptions about who and how participation can occur. These groups include the Brazilian group MSST (Movimiento Sem Satellites – the movement of those without satellites), the Mexican Collectivo Espaciale (the Mexican Space Collective), The Palestinian Space Agency, the Austrian art collective MUR that is launching a satellite called mur.sat, and the artist/hacker collective Orbitando Satelites. Though operating in different countries across the world these autonomous collectives could still be argued to be representing a specific genre of artist-led communities. Nonetheless the actions of these groups are indicative of a spectrum of independent spacefaring activities. To these artist-led activities could be added a growing popularity in launching personal video cameras into suborbital space using high altitude balloons. Putting in a search on YouTube for 'high altitude balloons' reveals a large number of such home made devices have been launched by groups of enthusiasts and some by families. A form of backyard spacefaring has begun to emerge. The freefall leap from suborbital space by Joe Kittinger in 1950 and more recently Felix Baumgartner in 2012 could be added to this spectrum, as could the emergence of commercial spaceflight projects such as by Virgin Galactic or the teams competing for the Lunar X prize. This new kind of space entrepreneurship challenges the imaginaries of national spacefaring by producing new uses of space technology such as space tourism and space hotels and bringing new kinds of cultural activity that expose the formalities of existing national space agency activities. The actions of the Moon Vehicle project can therefore be understood as having specificity but also having a relation to a host of other interventions that claim a more personal agency in spacefaring.

To consider another limitation, a research study such as this that calls into question the very ability to extrapolate and apply overarching principles or universals, has at the core of its methodology to resist doing the same. The thesis has achieved this in a very specific way, by drawing attention to seeing spacefaring from the perspective of the first-person. Furthermore, by calling on methodologies from subaltern studies a descriptive framework has been reached that accommodates the ways influence flows in entwined, rather than overarching, processes. In materialising aspects of imaginaries present in artistic and creative practice as well as indicating the reflexivity of viewpoint made evident by creative production as authorship, the thesis draws attention to seeing spacefaring from the perspective of the first-person. This proposition differs substantially from the overview perspective suggested by the very activities of spacefaring.

Suggestions for future work

According to the findings of this thesis, the proposition of spacefaring is an ongoing negotiation involving many actors into which artefacts such as this thesis intervene and modulate at some level. But is that enough? Has not the direction that spacefaring is taking, its belief system been pointed out as dangerous and violent (Nandy, 1988; Griffin, 2013a), limited in its critical reflection but with real power to cause environmental damage as well as to support agendas of cultural colonialism. If this is the case then the proposition this thesis offers may appear to bring little in terms of recommendations with which to act effectively and bring to account openly what are serious limitations in the intellectual frameworks in which spacefaring continues. In this regard a field to which the insights of this thesis could be directed in the future is Space Law and Space Policy. Space law mediates such questions of the effect of the enterprises of space agencies on a global humanity and has been doing so since the beginning of space exploration. Creative interventions, with tactics and arguably surreptitious methods could be seen as detracting from the formal processes of law and policy making for the commons of space and such interventions have been shown to be a test ground exposing hidden affect which future legal frameworks could encompass. A future theme of creative intervention would make useful alliances with the processes and discussions of space law. Laws are spaces of substantial negotiation between commons of many kinds in which, importantly, the viewpoint from the first-person and the relation of individual to state have to take on a more symmetrical relation through the frameworks of justice. But moreover, the themes, vocabularies and relations that become clarified through creative interventions considerably expand the existing scope from which laws and policies are formed. The notion and scope of 'authorship', for instance, as developed in this thesis extends the current use within space policy discourse of the term 'ownership'. Crucially, 'authorship' gives allowance for the influence and determinism of imaginaries on the shaping of the extra-terrestrial environment.

In relation to discussions about the interplay between science, technology and society, the propositions of this thesis can inform some assumptions on which these discussions often rest. In some ways it is by the act of authorship that intimate experience resists sublation into more anonymous collective idioms such as publics, society, science, technology. Yet it is by such acts of authorship that inevitably a commonality of experience is made recognisable and binds collective endeavours. Through many kinds of creative authorship the world is read and written from a first-person viewpoint. Drawings as acts of authorship not only trace the presence of creative agencies, but also consciously perform their very existence. In drawings and many kinds of creative practices, in the prototyping and operation of space technologies, in the interpretation of data and in the interpretation of technoscientific practices, authorship is present, but only sometimes made visible. Authorship is valued in different ways in different fields but where it is recognised is an activity redolent with meaning and agency. It may be that it is through interaction with creative disciplines that actions and activities in technoscientific domains become foregrounded as types of authorship. Viewpoint and experience thereby provide guides to the nature of the translations and assimilations of space technologies within social domains through myriad acts of authorship.

The thesis makes a crucial addition to discussions about the interplay between sciences, technologies and society through the recognition of the intimate spaces at the core of such large-scale concepts. This has implications for discussions of science and society and the nature of deliberative processes by which the scientific and technological are assimilated. The notion of authorship has been proposed by the author in such forums (Griffin, 2013b) and is relevant also to the practice of science communication as well as for wider discussions on democracy and political process where assumptions are made about the need to draw publics in to deliberative processes. This thesis suggests that the ways political opinion forms and is expressed cannot be assumed to take on one particular mode, but rather shift in form of expression, site of expression and actions themselves. Non-participation is a signal also that can describe the lack of availability of opportunities for interaction and crucial spaces of resistance and dissent. Care is needed therefore in studies and processes that may overlook the subtle nature of non-participation, which is often assumed to indicate ignorance or indifference. Non-participation is part of a continuum that includes the displacement or sharing of action and critical reflection between persons and between seemingly unrelated registers.

The example of spacefaring has transferability to other large-scale problems that require planetary level response. The findings of this project indicate how the planetary scale gives a misleading sense of obtaining knowledge. It can be argued that spacefaring does not any more make a serious claim to be acting for humanity. It is clear from many space projects how the economic stimulus of space projects is extremely effective in galvanising innovation, for which the adventure of space travel becomes an attractor and motivator. The thesis has used the claim to be acting on behalf of all humanity to instead open up a grey area of thinking. At the root of this problem, it has been argued, is a gap in appreciation of the nature of the affective spaces of the space industry, how it makes people feel, how it affects choices on a number of registers that can seem unrelated to space enterprises. To appreciate this realm of effect and affect the work of Latour provides a language, evidence and models of thinking. The work of de Certeau also rectifies the anonymity placed on ways of life that lack the definition afforded by architectures of institutions such as space agencies. While artistic intervention makes visible or creates spaces of agency, in the same instance, because of the exceptional nature of the interaction, it exposes the lack of such opportunities. It sheds light on a lack of clarity about how spacefaring is adopted, used, of benefit, participated in by wider publics. It exposes a structural lacuna in the connection of the theatre of space technology to its audience

The thesis has defined how the multivalent visuality of art practice acts as a heuristic device for recognising conditions in the social domain of space technologies. The technology of space instrumentation and its scientific, economic and political imperatives is bound into potent imaginaries that camouflage a flawed attempt at a gesture of planetary significance. But the structural flaws in the rationale of spacefaring provide an extremely rich guide for other situations that ostensibly require a species level response or action. The faults, inadequacies, blind spots, the propositions, implications and imaginaries fuelling the pursuit of ambitious extra-planetary goals, can be learnt from. Spacefaring, complete with its faults, viewed through an artistic lens as possessing a subaltern aesthetic, can shift in its primary purpose and become a guide or a prototype for other large-scale or planetary-scale imperatives that need to be faced. A key original contribution the thesis makes is to define how viewpoint and experience foreground heterogeneous affective spaces in which a spectrum of critical resistances are an active part of a spacefaring technography. By picturing the interrelations and flows of space technology in social domains through the lenses of experience and viewpoint, the prototyping work of space technology then becomes available to be re-imagined and grounded within intimate readings.

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Interviews:

Geetha Narayanan (Founder/Director Srishti School of Art, Design and Technology), Bengaluru, March 2008.

Rakesh Sharma (ISRO astronaut), Bengaluru, March 2008

Sunil Kumar and Sadhana Kumar (Curators of Visvesvaraya Industrial and Technological Museum), Bengaluru, March 2008.

Sundar Sarrukai (National Institute of Advanced Sciences), Bengaluru, March 2008.

Carle Pieters (Principle Investigator Moon Minerology Mapper team), Bengaluru, February 2009.

Shyama Narendranath, Manual Grande (C1XS instrument team), Bengaluru, February 2009.

Ramya S (Researcher), Indian Institute of Astrophysics, Bengaluru, 7 October 2009.

Scientists at the Mullard Space Science Lab, UK Monday 2 November 2009.

Ewen Chadronnet (Artist), Bengaluru, November 2009.

Biswajit Paul (Astrophysicist), Raman Research Institute, Bengaluru, 15th March 2010.

P Sreekumar (Co-Principle Investigator C1XS instrument) , Raman Research Institute, Bengaluru, 9 August 2010.

Jayanth Murthy (Astrophysicist, Indian Institute of Astrophysics), Bengaluru, 3 September 2010.

Sunil Kumar (Curator of Visvesvaraya Industrial and Technological Museum), Bengaluru, 17 August 2011.

Amrita Shah (Biographer of Vikram Sarabhai), Indian Institute of Science, Bengaluru, 29 August 2011.

P Sreekumar (Co-Principle Investigator C1XS instrument) Raman Research Institute, Bengaluru, 7 September 2011.

Sreenath (ISTRAC data system scientists) Bengaluru, 14 September 2011.

Dilip Ahuja, (National Institute of Advanced Sciences) Bengaluru, August 2011.

Appendices

Appendix 1

Diagram created by the author near the beginning of the Moon Vehicle project indicating the scope of the project.

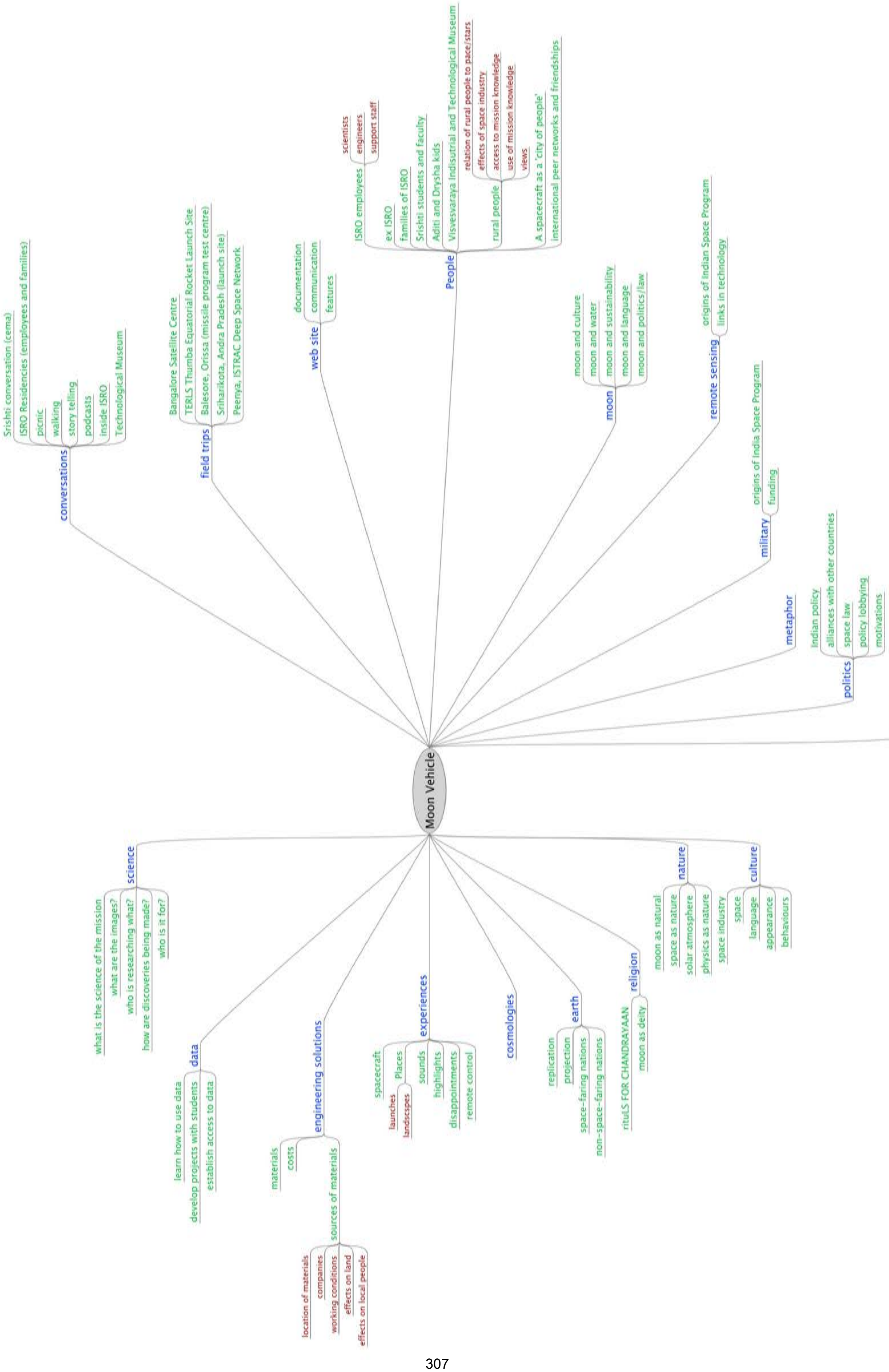
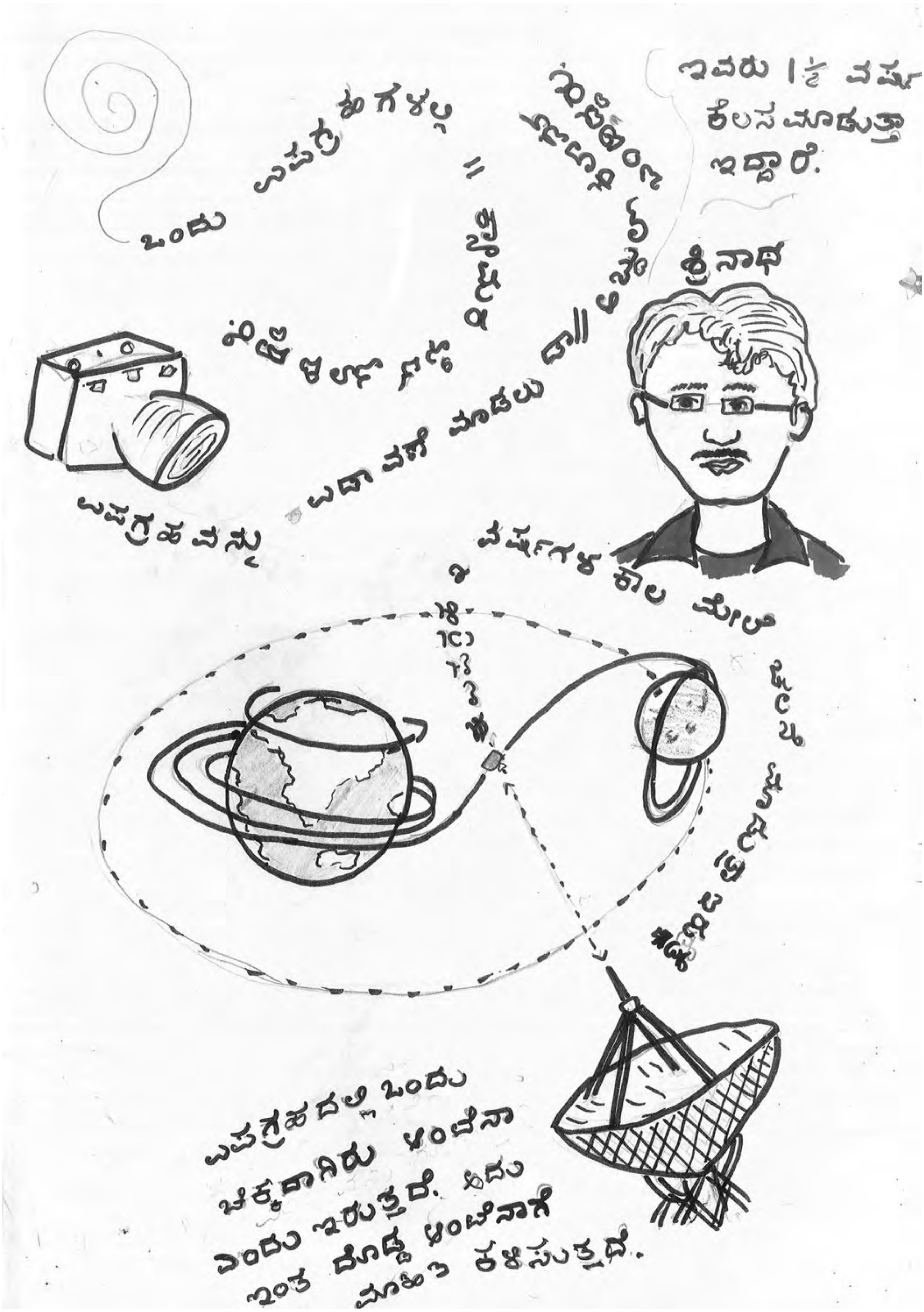


Diagram created by the author near the beginning of the Moon Vehicle project indicating the scope of the project.

Appendix 2

Citation: Griffin, J. (2012) 'Moon Vehicle: Reflections from an artist's-led children's workshop on the *Chandrayaan-1* spacecraft's mission to the Moon'. *Leonardo*, 45 (3). pp 219-224.

Leonardo Journal homepage: http://www.mitpressjournals.org/loi/leon


ಇವರು 1½ ವರ್ಷ ಕೆಲಸ ಮಾಡುತ್ತಾ ಇದ್ದಾರೆ.
ಶ್ರೀನಾಥ
ಉಪಗ್ರಹವನ್ನು ಉಡಾವಣೆ ಮಾಡಲು
ಉಪಗ್ರಹದಲ್ಲಿ ಒಂದು ಚಿಕ್ಕದಾಗಿರು ಆಂಟೆನಾ ಎಂದು ಇರುತ್ತದೆ. ಇದು ಇಂತ ದೊಡ್ಡ ಆಂಟೆನಾಗೆ ಮಾಹಿತಿ ಕಳಿಸುತ್ತದೆ.

ARTIST'S ARTICLE

Moon Vehicle: Reflections from an Artist-Led Children's Workshop on the *Chandrayaan-1* Spacecraft's Mission to the Moon

Joanna Griffin

ABSTRACT

This article reflects on the journey to the Moon of the spacecraft *Chandrayaan-1* as it was interpreted through an artist-led workshop. The workshop participants were a group of children who lived close to where *Chandrayaan* was built and some of the engineers and scientists responsible for creating the spacecraft. Insights from the workshop show how a mission to the Moon draws on both the technological and the imaginative; they also have bearing on the relative agency of these individuals to contribute to the Moon missions in ways that are personally meaningful to them.

The 2-week children's workshop that is the focus of this article was held at Drishya Learning Centre, located in one of the urban slums of Bangalore, India. The workshop was one of many events in a long-term project called Moon Vehicle, begun in March 2008, which was based out of the Centre for Experimental Media Arts (CEMA) at the Srishti School of Art, Design and Technology in Bangalore. Srishti is one of the foremost design institutions in India and has a commitment to pioneering art/science projects. The catalyst for the Moon Vehicle project was the launch from India in October 2008 of the *Chandrayaan-1* spacecraft, which is currently out of contact at an unidentified location in the vicinity of the Moon, where it was sent to collect data on terrain, minerals and the enigmatic possible presence of water. Moon Vehicle is a translation of the Sanskrit word *chandrayaan* and was conceived as a vehicle through which the cultural dimensions of the mission could find a space to be articulated. The idea for this art/science project came about during the Bangalore Space and Culture Symposium in 2007 [1]. This symposium comprised a mixed forum from the communities of the sciences and the arts, in which speakers from the Indian Space Research Organisation (ISRO) gave presentations alongside artists and theorists.

The resonant point at which to begin the story of this workshop is that of a meeting that took place in which representatives from the Space and Culture Symposium organizing committee approached ISRO to formally request that collaborations begin across their disciplines in order to celebrate the coming launch of *Chandrayaan* and its anticipated combination of cultural and scientific dimensions. Unfortunately, the response from the space agency was a resounding "no." The representatives from the art and design communities were asked to come back when ISRO needed its spacesuits designed! This rejection, of course, only added urgency to the cultural mission. It also indicated that the operating space for the Moon Vehicle project would be at the fringes of ISRO and would take shape via unofficial, informal negotiations.

A short time after these events, I began a two-year appointment as artist-in-residence at Srishti, in the role of mentor to the Moon Vehicle project. Many of the outcomes of this project were devised with students from Srishti and offered ways to share and elicit common understandings of the Moon. The use of a projection of the Moon's image via telescope onto the ground became something of a motif for the work. Looking down at the Moon instead of up at it created a poetics of inversion that opened new spaces for thinking about its image, bringing up questions of the relation between the Earth and the Moon and the treatment of each. The image on the ground naturally organized people into a circle, in which the acoustics were perfect for many kinds of sharing and storytelling to occur. The projection also made it possible to sit or stand on the Moon (Fig. 1), and this location brought with it perceptions that might not otherwise have been accessed.

In describing the workshop, which built on these sharing events, it is necessary to indicate something of the specificity of the context in which it came about. The poetic reorientation that placed the Moon on the surface of the Earth helped draw out a set of nuanced, ongoing, provisional, localized and personal relations with the Moon of the kind often lost in the grand narrative of institutionalized space technology. It is with a similar emphasis on the nuanced, localized and personal that the Moon Vehicle workshop is shared here, not as a model education project to be repeated elsewhere but rather to show what a necessary stage in finding the meaning of a techno-scientific Moon mission looked like in practice. What happened was particular to the time and place, fulfilling a need not otherwise being met. It addressed a continuum of needs, motivations and opportunities and emerged by way of a series of serendipitous, fortuitous, intended and unintended encounters. However, it also took place within a larger, historically contingent framework.

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Article Frontispiece. Drawing by Prashant-J made at the Indian Deep Space Network, Byalalu, Bangalore. (Photo © Joanna Griffin) The drawing shows the path of *Chandrayaan-1* to the Moon together with the telemetry between the spacecraft and the receiving dish at Byalalu. The scientist who explained this is depicted.

Fig. 1. The image shows one of the ways the projection of the Moon was used during the Moon Vehicle project: as a way of eliciting a personal experience of the Moon. (Photo © Joanna Griffin) During a workshop about imagination and technology, a student is explaining how she became stranded on the Moon.

Context and Ideologies

The *Chandrayaan-1* spacecraft, the Moon Vehicle project and the model of pedagogy developed at Drishya Learning Centre correspond to the domains of spacefaring, experimental media art practice and radical education. While there are many factors that influence a course of events, some recognizable and others less so, what appeared to be the common thread that galvanized these groups at that particular time and place was a shared aspiration to transform an identity. The *Chandrayaan* mission, the Moon Vehicle intervention and Drishya's education philosophy each had an identity and a narrative to dislodge and reclaim. While *Chandrayaan*'s work was in part to dislodge the perception of India as a developing nation by showcasing spectacular technology, the art-and-culture project Moon Vehicle was intended to dislodge the now-dominant scientific narrative of the Moon with a broader critical-cultural frame; the Drishya education movement sought to dislodge stereotypical notions of what underprivileged children should or should not learn and aspire to. Each needed to unlock the energy of the other to transform a dominant narrative.

A crucial factor to understand in building the context of *Chandrayaan* is the particular notion of "science" in India. Jawaharlal Nehru, who became India's first prime minister after Independence in 1947, held a strong conviction that science had to be an integral part of nation-building, as it could be used to alleviate poverty and many other problems the nation faced at the time. As a consequence, the Indian constitution notably contains a clause stating that one of the duties of the citizen is to develop the "scientific temper." The founder of the Indian space program was Vikram Sarabhai. He and Nehru were close friends and had similar ideas. Thus a powerful tie of space technology to the transformational potential of science through nation-building is forcefully present in the collective imagination of *Chandrayaan* within India [2]. This Moon mission also holds particular significance within the story of India's 50-year satellite program. Up until *Chandrayaan*'s launch, India's highly successful space industry had focused on the Earth, on remote sensing and communication applications, in a uniquely poetic alliance between high-end technology and grassroots needs. The initial purpose of India's space program was to study the atmosphere in order to produce better information on weather patterns and so to help farming. From this, Sarabhai recognized that satellites could also be used to provide communications for villages, which at the time were extremely isolated, through satellite broadcast television, providing education and the distribution of information on farming and healthcare.

The vision expressed by Vikram Sarabhai, that space technology would be used to alleviate the immediate problems of India's people, reflected a quality of humility lacking in the competitive Space Race drama being enacted between the U.S.S.R. and U.S.A. There was a clarity and sincerity to his purpose, a rationality and logic to his proposals and above all a humanitarian vision. It is notable that he would not be drawn into the political vanity of Moon missions. He rejected any idea of Indian spacecraft going to the Moon and mistrusted what he saw as the questionable motives of such a journey, saying, "If we are to rely on historical experience, man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed" [3].

In the light of this founding ideology, the mission of *Chandrayaan* marked a 180° turn in viewpoint both from the Earth and from this respectable philosophy. The hitherto altruistic ecology of the space program lost, in the case of *Chandrayaan,* a recognizable connection to the people of India. The Moon Vehicle workshop then fell bluntly into the conceptual gap and asked the awkward question of the relevance of the Moon mission to the people of India and particularly to the issue of poverty. While it is right to ask this question, it is itself a question beset with assumptions that hang on the narrow definitions of identity and presumptions of need assigned to poverty [4]. Nowhere are these assumptions about identity and need more strongly opposed and more clearly articulated than by the communities that are so labeled. The Drishya Learning Centres [5], located on illegally occupied land (slums) in several areas of the city, proceed from a robust philosophical framework that promotes self-determination. In this encounter with the space agency, Drishya helps to expose the type of relative and nuanced spaces of agency available to individuals, who are consistently factored out by the sheer scale of operation of a space program and its thinking space, however humanitarian its motives may appear.

The idea of spaces is fundamental to the Drishya philosophy. The poverty of slums leads to highly localized communities, because their occupants are literally not able to go far and because necessity creates strong local bonds and reliance. Drishya (a Sanskrit word meaning vision) prides itself on transcending location, and it may be that this physical release from place is also a means to overcome a grueling situation. The children at Drishya learn that they are

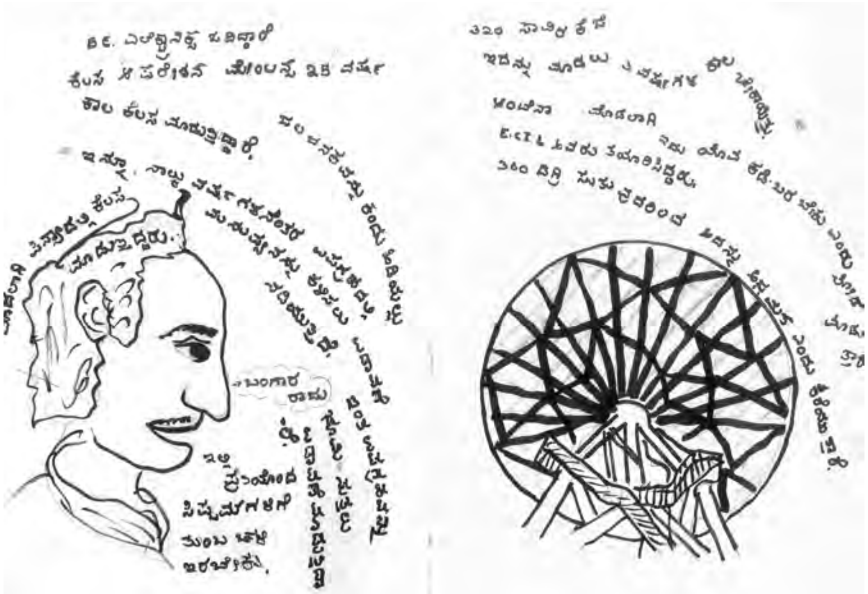


Fig. 2. Drawing by Prashant-J made at the Indian Deep Space Network at Byalalu, Bangalore, showing the back of the 32-m receiving dish and one of the operators explaining how it works. (Photo © Joanna Griffin) The writing explains that the operator has been on duty for 25 years, that they are looking for water or oxygen on the Moon and will send humans there, that the systems have to be kept extremely cold and that the antenna weighs 320,000 kg.

not geographically bound to the slum area any more than they are bound to a way of life in which they lack agency. Any kind of stereotyping is strongly opposed. Mobility within a network of learning is emphasized, such that learning takes place across locations, collaboratively, very often using the energy of artists' investigative methods to drive projects [6].

This is the context in which the workshop began, and as a consequence it appeared to have been eagerly awaited by all concerned.

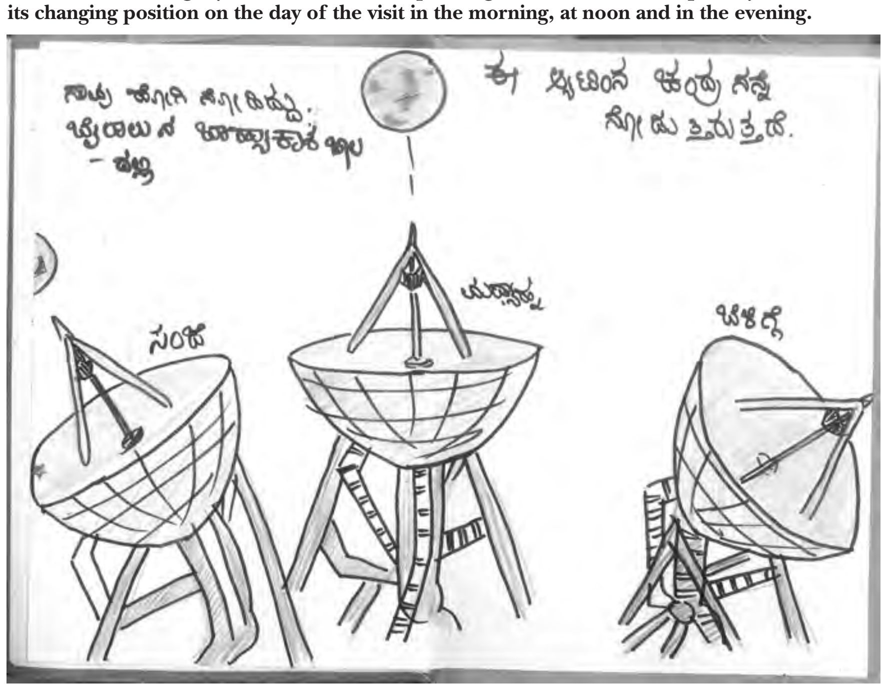
Days of the Moon

At Drishya, each day begins with a mandala, a circle on the floor made with colored sands and whatever else the children decide to value that day. Essential oils chosen for their calming attributes, incense and a prayer give focus and harmony to a short period of meditation during which the children and facilitators sit in a circle. The children will often say this is the most cherished moment of their day. It marks a disjunction from home life. It demarcates a new space, a special space for learning about the world and self.

On the first day, the workshop team—consisting of Vidya Prakash, the children's facilitator; Anitha Santhanam, a physical theater practitioner; Babita Belliappa and Alisha Panjwani, two Advanced Diploma students from Srishti specializing in language and digital media; and myself—set up questions and starting points. First was the question of how we explain things we do not understand. There are stories of the Moon—for instance, that of the Sun and Moon being angry brothers chasing each other—that explain why the Sun and the Moon follow the same path. The current science about the Moon continues to offer explanations that displace previous scientific stories into myth. To illustrate how stories emerge from the effort of trying to make sense of the world, Santhanam asked the children to work in groups and depict fabulous phenomena, for which the other children had to develop explanations. Later she asked the children to bring in an object that meant something to them and to describe the object in scientific terms ("the ring is made of gold") and in personal terms ("my grandmother gave it to me"). She said that every object has a factual side and an emotional, experiential side. The Moon, she said, is both science and culture: It can be described through science and given meaning through culture.

Moon means satellite, so the concepts we explored next were those of *satellite* and *orbit,* in order to see how the defining principles of the physics of our solar system also defined our more immediate world. Each of us took a paper plate, drew ourselves in the middle and then created a diagram of the things and people that we felt were in our metaphorical orbit. There were parents and aunts, dogs and the mandala. From that process it became clear that some things were difficult to place, because someone who meant a lot might be physically far away, and that valuing things brings them close in meaning. After this the children made a representation of the solar system on the floor. Where was *Chandrayaan*? The children knew all about *Chandrayaan.* They had watched its launch 8 months before and collected press clippings,

Fig. 3. Drawing by Prashant-D of the receiving dish at the Indian Deep Space Network following the Moon and communicating with the spacecraft *Chandrayaan-1*. (Photo © Joanna Griffin) The writing says that the antenna is pointing at the Moon in the open sky and shows its changing position on the day of the visit in the morning, at noon and in the evening.



but its link with the Moon was still a little flimsy. No one was quite sure where *Chandrayaan* was.

On the second day, we visited the ISRO Satellite Centre, where *Chandrayaan* was built. As with all space agencies, there were lengthy security checks—no cameras, no phones, no memory sticks. The group was taken to see a museum of satellites and learned that a satellite is different from a rocket. Next was a window into the "clean room," the dust-free satellite-building workshop, where engineers wear white coats, caps and face masks. Here CartoSat II was being built. It was covered in gold blankets, and one of the students asked if this were similar to the gold covering on chocolate bars that stops them from melting. It was similar. In the offices of the scientists and engineers working on X-ray instrumentation, the children were told the different theories of how the Moon was formed, that a rocket, once launched, separates into three parts called "stages" and that one day the Sun would expand due to helium depletion and swallow the nearby planets, including Earth.

After this visit to Satellite Centre, the children's facilitator Prakash bought a bagful of hospital caps and masks, like the ones worn by the clean-room engineers, so that the children could create their own "clean room" at Drishya. It was a role-playing exercise meant to ease the stark division they might have experienced the previous day when looking in on the white-coated engineers through the glass of the public viewing gallery. Wearing facemasks and caps, the children became the engineers and, with stunning recollection of the shapes, instrumentation and solar panels required for spacecraft engineering, they built their own satellites. Undaunted by the hierarchy and ritual witnessed in the ISRO "clean room," they made wry comments on these observations through objects, among which were a white-coated rocket and a mini-satellite with a button-down shirt.

The second field trip was to the Indian Deep Space Network (IDSN), the state-of-the-art tracking station built 30 km south of Bangalore at Byalalu village. In less than 3 years, ISRO problem-solved its way to creating its own deep space network. When I visited the dozen engineers who operated the facility, they seemed to me understated geniuses, deeply immersed in the language of the machines they had designed and talking in a series of acronyms. They made us feel welcome and comfortable in their half-empty buildings that eagerly anticipated India's future deep space missions.

Partly in response to the ban on photographs at ISRO, I asked the children to make drawings while they were on site. In addition they had to interview the scientists and create what I called "interview portraits." These were depictions of each person with the technology they spoke about and had built or were working with. I wanted the children to think of technology not as self-contained objects but as human enterprises: the outcome of somebody's idea, many ideas from many individuals, materialized into a spacecraft and its apparatus of rockets, antennas and computers. Spacecraft, in their intricate making, give expression to multitudes of questions about why and how we are here on Earth and what it is that surrounds us. As a foreigner, I had not been allowed into Satellite Centre, which is the most secured of ISRO's bases, and somehow the tight orchestration of the children's visit there had left no time for drawing. However, here in the open landscape, with the Moon above us in a blue sky, the children began their drawing task in earnest, and our wonderful hosts were bemused as they, as much as the technology, became the subject of the drawings (Fig. 2).

The drawings traced the children's newfound connection to the Moon and *Chandrayaan* through conversations, questions and jokes between them and the keepers of the spacecraft (Article Frontispiece). Their understanding of a pathway to the Moon from the local Satellite Centre took shape in their drawings. Now we all knew where *Chandrayaan* was, we knew where it had been made and we knew which route it had taken to find the Moon.

Perhaps the most compelling connection came at the end of our day at the Deep Space Network. We had gathered under the white receiving dish, which spanned 32 m and dominated the wide rural landscape as it followed the path of the Moon from horizon to horizon every day. The children finished their drawings in the shadow of the antenna, and we all seemed to linger; no one wanted to go home. I think we might have felt closest to the spacecraft then, seeing the Moon in the sky and the antenna pointed at and seemingly pulled along by our distant friend *Chandrayaan*. It was a gentle, pastoral scene, in which something profound was taking place—a conversation between the gargantuan dish, Chandrayaan and the Moon (Fig. 3).

TRANSFORMATIONS

After our field visits, the group set to work reconstructing our encounter with *Chandrayaan*'s Earth station. Every morning the children worked on developing stories and performances based on their encounters with ISRO. In the performances, the children began to take on the characters of the antenna (Fig. 4), the Moon, *Chandrayaan* and even the telemetry, which danced between the two. The antenna sent questions for *Chandrayaan* to ask the Moon and these were relayed back and forth, with inevitable confusions. One of the performances

Fig. 4. Rehearsal of a performance that depicts the movement of the receiving dish that was seen on a field trip to the Indian Deep Space Network, Byalalu, Bangalore. (Photo © Alisha Panjwani)

Fig. 5. Drawing by Yerlumalai that depicts, to the left, the Moon with the orbiting *Chandrayaan-1*, of the kind used in promotional material, and, on the right, dancing moons with explanations inside of the various things *Chandrayaan-1* is doing while at the Moon, such as taking pictures, looking at X-rays and orbiting. (Photo © Joanna Griffin)

made fun of the security guards, who had been unremittingly brusque with the children. Another explained the three stages of the rocket and that the satellite sits inside the tip of the rocket, which is called the nose cone. The factual narrative combined with an exquisite economy of movements in which the first two rocket stages transformed themselves into the Moon and the third into *Chandrayaan*. During the final presentations on the last day, to an audience that included scientists from the Indian Institute of Astrophysics, the most laughs came for the story of Amavasya (meaning new moon), in which the Moon acts suave and cool as orbiting satellites take its picture, but then gets tired and decides to go away for a while, which becomes the reason why the Moon appears and disappears every month. The fewest laughs were for the story of Pluto, driven out of his house by abusive parents, who then regret their ways and send a satellite to find him. Other stories told further tales of bullying, inequity and reconciliation. Away from the ISRO base and its dominating materiality, the technological objects were reused by the children in scenarios that had resonance and meaning for them. The technology began a new journey of imagination.

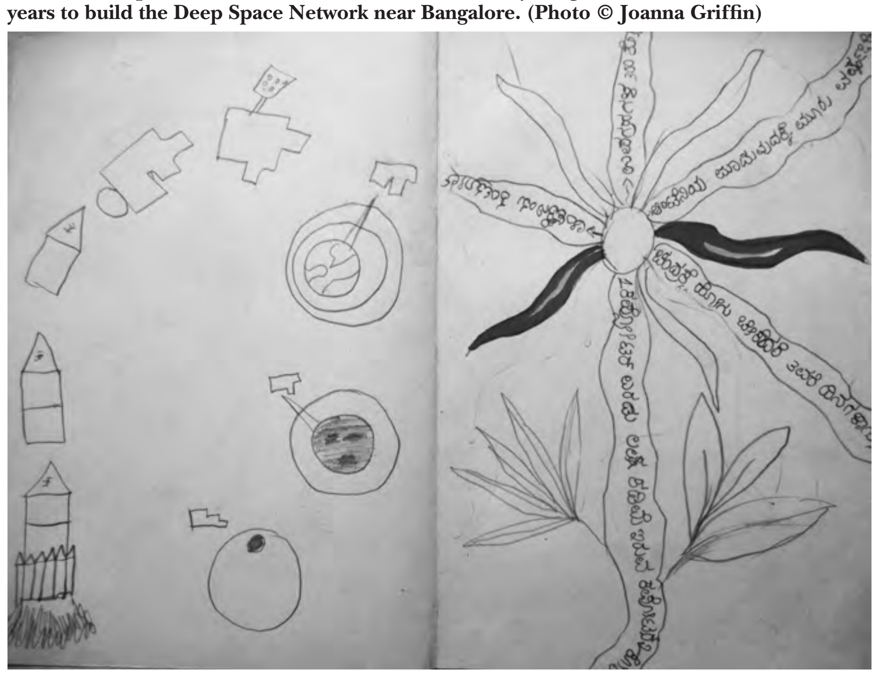
The drawings shared this embodied, theatrical method of transferring the technical rationality of the Moon mission to the nuanced subjectivity of personal experience. In Yerlumalai's drawing (Fig. 5), for instance, an image derived from an ISRO information leaflet appears next to fantastical moon creatures with arms and legs.

With a similar freedom, the clear, linear pencil sketch by Shivashakti (Fig. 6) puts the hard information of the cost of the mission (300 *crores*, a numeric unit used in India equal to 10 million), the amount of time it took to build the antenna (3 years) and the days *Chandrayaan* took to get to the Moon (3) into the petals of a huge flower, as her way of making sense, at that particular time and place, of the oddly poetic numeric facts with which *Chandrayaan* was constantly described.

These images and performances are a window into some of the unpredictable and enriching ways in which individuals construct meaning and make sense of the world. They illustrate drifts of thinking, involving remixing, association and transmutation, and help to indicate the boundless field of imaginative participation that can be generated from spacefaring activity.

These kinds of transformations of the Indian Deep Space Network and *Chandrayaan* into theater and drawing could be seen as the kind of imaginative leap of which only children are capable. However, from my conversations during the project with the Byalalu team of scientists, engineers and computer programmers, it was clear that they would also have been open to such invention, indicating that the emergence of these associations is merely contextual. What is it that prevents these translations from taking place more widely, when the potential for association is so tangibly present in the technology? Would the dream space of these artifacts, if more fully extrapolated through cultural production, have the power to induce new forms of usership or of agency? Could the spacecraft that fled the Earth and has now lost

Fig. 6. Drawing by Shivashakti showing, on the left, the rocket stages and journey to the Moon of *Chandrayaan-1* and, on the right, a huge flower with information about the mission written in the petals: The cost is 300 crores; it took 3 days to get to the Moon; and it took 3 years to build the Deep Space Network near Bangalore. (Photo © Joanna Griffin)



contact with its creators be appropriated and reshaped by attending in such ways to the imaginary?

In thinking through such questions, it should not be forgotten that the task of creating a mission to the Moon was itself a colossal act of transformation from idea to material. It could be said that engineering holds the key to a true poetics of a human relation with the Moon, containing in that relationship a vast knowledge, a complexity of materials, physics and processes that define in superb detail a tangible relation with the distant Moon. The spectacle of technology forms a conduit by which new kinds of meanings and emotional connection are made evident. It itself creates an image. The bizarre collage that constitutes the landscape of village and deep space network at Byalalu is the product of a method of scientific and technical rationality originating from an imaginary and visionary place. It is itself a kind of theater.

That *Chandrayaan* did leave Earth orbit was a historic moment for the identity of India, indicative of the completion of a certain kind of nation-building and that a certain kind of transformation had taken place. For many of the scientists, engineers, directors and team leaders I have spoken to about their roles on the *Chandrayaan* mission, it is this achievement that had the most meaning; it was from this place that the unexpectedly emotional charge of the mission would hit. *Chandrayaan*'s successful journey to the Moon released a burden of identity that, 40 years earlier, Nehru was determined would be overcome through developing the scientific temper.

Conclusion

The Moon Vehicle workshop has been used here as a mechanism for unlocking aspects of the overarching narrative of science and technology in India, which, post-Independence, has been punctuated by the idea of scientific temper. Nehru's delicate phrase, which has been hotly debated in India for decades [7], has a profound resonance on the subcontinent but is rarely heard elsewhere. It is a useful phrase that tempers the notion of science, giving latitude to contradictory experience and at the same time propelling an ongoing criticality.

One of its consequences has been this encounter between Drishya Learning Centre and the Indian space agency ISRO, using artistic practice as a medium of translation. Art practice has methods for making unfamiliar thinking become more easily apparent often through acts of inversion, such as projecting the Moon's image onto the surface of the Earth. In the encounter described in this article, the unacknowledged ways that space agencies learn from the poetics of their visiting children is just one among many insights that can begin to take form through this method of working.

The entwined relations between space technology, humans and environment revealed by way of the Moon Vehicle project shed light on aspects of the relation of space technology to the public domain that appear when the imaginary dimension of the space agency is considered. From my perspective as an artist, such relations are transmitted in the images and theater produced by the children. I suggest that attending closely to these translations reveals other criteria for thinking about the meaning of space technologies.

Acknowledgments

Much appreciation goes to the children from Drishya who participated in Moon Vehicle workshops, to the workshop team of Vidhya Prakash, Anitha Santhanam, Babita Beliappa and Alisha Panjwani and to the scientist and engineer collaborators from ISRO who gave their energies to the workshop and shared their extraordinary experiences. I would particularly like to thank Geetha Narayanan for proposing the workshop and for providing the support and vision necessary for such a project as Moon Vehicle.

The comments and advice given during the writing of the article from Martha Blassnigg, Vasanthi Das and Michael Punt, as well as from the anonymous peer reviewers, were immensely helpful.

References and Notes

Unedited references as provided by the author.

1. The Bangalore Space and Culture Symposium took place at the National Institute of Advanced Studies, Indian Institute of Science, Bangalore, India, 29 September–1 October 2007. The organizing committee included Srishti School of Art, Design and Technology; *Leonardo* journal; the National Institute for Advanced Studies; and the U.K.-based art/science agency The Arts Catalyst.

2. In 1962 the Indian National Committee for Space Research (INCOSPAR) was formed within the Department of Atomic Energy with Vikram Sarabhai as Chair. This became the Indian Space Research Organisation in 1969. The biography by Amrita Shah, *Vikram Sarabhai: A Life* (New Delhi: Penguin Viking, 2007), is a good source for understanding the person, the context and the emergence of an ideology around this technology.

3. The speech by Vikram A. Sarabhai, "Sources of Man's Knowledge," was reproduced in *Resonance* (December 2001 p. 92) and was originally delivered in 1966 as part of the National Programme of Talks, Series: "Exploration in Space."

4. Amartya Sen writes in *Development as Freedom* (Oxford: Oxford University Press, 1999) of "the terrible burden of narrowly defined identities" (p. 8) and provides an articulate framework by which human-centered values can be better accounted for in economic theory.

5. Drishya began in 2002 and is run by Anita Reddy. Its education program was developed by Geetha Narayanan, who is the Founder/Director of Srishti School of Art, Design and Technology, with her research collective Project Vision. The concepts and history of Drishya are described in "Dwaraka Drishya: An education movement empowering poor children" (2005) 19 May 2010 <www.dwarakaonline.com/Html/Drishya.htm>. See also Ref. [6].

6. The philosophy that frames Drishya can be researched further in a number of online papers and presentations by Geetha Narayanan, such as: "Crafting Change II: The Project Vision Hypothesis," presented at the Global Summit 2006: Technology Connected Futures, 17–19 October 2006, Sydney, Australia; and "A Dangerous but Powerful Idea—Counter Acceleration and Speed with Slowness and Wholeness," (2007) [Online]. A paper by Arzu Mistry, "Linking the Arts and the Environment" (2009), presented at Arts Education Conference: Contexts, Concepts and Practices in Schools, 11 and 12 December 2009, Bangalore, India, was also helpful in making explicit how artist interventions contribute to the curiosity-driven curriculum of Drishya.

7. Meera Nanda's *Prophets Facing Backwards: Postmodernism, Science, and Hindu Nationalism* (Delhi: Permanent Black, 2004) has a chapter exploring the discussions that arose particularly in the 1980s over the interpretation of the term *scientific temper*; and the anthology edited by Ashis Nandy, *Science, Hegemony and Violence: A Requiem for Modernity* (Delhi: Oxford University Press, 1988) also gives a good sense of who was critically involved and what was at stake.

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Appendix 3

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Hitchhiking to the Moon

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Prologue

A few months ago I presented a paper at the 63rd International Astronautical Congress,[1] the annual gathering of the space technology community, which includes astronauts, entrepreneurs, scientists, technologists, space lawyers, educators and also, more recently, artists like myself, who have undertaken space-related work and now have a mini-symposium of their own within the umbrella congress. I presented at the artists' symposium, but also at the symposium for small satellite missions, entitled 'Hitchhiking to the Moon'. The idea of the session was that small satellite 'payloads' (the separate working instruments inside the satellite) could get lifts to the Moon economically on larger space agency missions. The title was also a play on Douglas Adams' radio play and book *The Hitchhiker's Guide to the Galaxy*. As a non-technologist and artist, I took up the invitation to hitchhike with the real space technologists and present outside of the artists' nominated stream, with the hope that some of the ideas that seem to be absent from the satellite technologists' purview might have a better chance of being heard.

What is presented here is a version of that paper, written without the same caution and careful language that was needed the first time round to convey, in a reasonable and credible way, what appear to me to be the blatantly colonial practices of spacefaring. Space exploration often seems unassailably guarded by a teleological account of human evolution in which going into space is 'the logical next step'. This phrase appears regularly in space industry rhetoric. Its certainty is reinforced by the imagery of science fiction that supports the space industry. Kubrick's sequence in the film *2001: A Space Odyssey* (1968) of a bone being thrown into the air by a hominid and transforming into a spaceship confirms an imaginary that has been deeply persuasive in justifying a vast and complex worldwide industry. This spacefaring imaginary seems to have always existed as a certainty, with no clear root or origin from which to question its logic. That the survival of the species depends on humanity's ability to live beyond Earth remains a central belief of the technoscientific and entrepreneurial communities that are most closely involved in determining the technologies of space. So it is that, within the apparent pragmatism of the space agency workplace and supported by the seemingly unquestionable rationality and stability of scientific discipline, spaceflight harbours ghosts of futurity, naturalised into its fabric, that are dangerously anachronistic.

This paper is about the ideologies that hitchhike to the Moon via spacecraft technology, the ideologies from which spacecraft technologies that go to the Moon are built, and the space available for the modulation of these ideologies. It is also, in a sense, concerned with how to talk about this, how to put one discourse into another, how to be transdisciplinary and where to be transdisciplinary. This paper, then, is a version of the paper given at the conference, inside a reflection that situates it in its performed context, as both an intervention and an experiment in transdisciplinarity.

Introduction

This is a paper by an artist who often works within education and is also a researcher with the Transtechnology Research Group at the University of Plymouth in the UK. This group undertakes research from the angle of non-technologists (as artists, designers, anthropologists, curators and archivists) in order to develop new perspectives on technologies. It uses a transdisciplinary approach, which allows for a certain freedom to move across disciplinary fields. The subject of this paper is an exploration of what satellite missions – particularly ones to the Moon – mean to those directly involved in the making of such missions, as well as to those who feel they are affected by them even though they have no tangible relation to the workplaces from which these missions emerge. It therefore concerns a combined field made up of those with and without a satellite.

One of the aims is to describe the reach of space enterprises in ways that would help situate a community such as that represented by the International Astronautical Congress in a dynamic relation with what is currently defined by the misleading and misunderstood concept of the 'general public'. I want to begin by using two thought experiments, exploring notions concerning travel and translation, to indicate how redefinitions could start to occur.

Travel and translation

The first thought experiment poses the question, "What is 'landscape' and 'world' when it is other than Earth?". To resituate thinking and language that have evolved in relation to this planet to environments in which light, air, touch and sound have entirely different meanings is to interpret phenomena in relation to

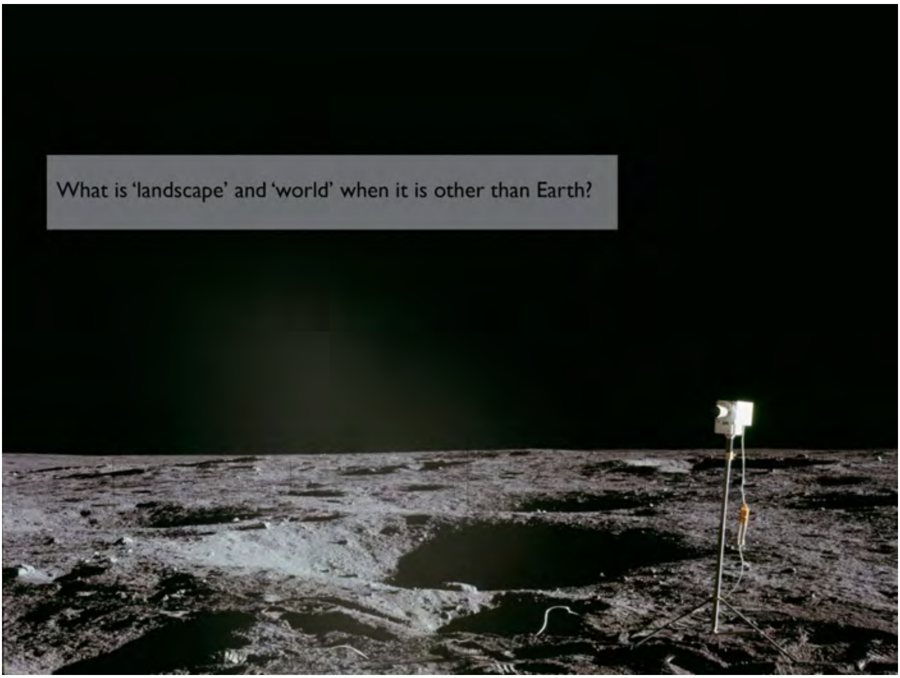

Fig. 1: Photograph from the Apollo 12 mission: "Failed TV camera"

the established order of things on Earth, thereby misinterpreting other planets. Language and experiences learnt on Earth will always be proxies for something essentially never-before-encountered, the unknown. To imagine the entirely unknown and un-experienced requires great resources of imagination in order to think away from planetary assumptions specific to Earth. This is what is so impressive about decisions to visit other planets, because to do so requires a colossal ability to be open-minded, to let go of habits of thinking and learn from scratch a new vocabulary and new ways of being.

However, it seems that journeys to the Moon or other planetary bodies are rarely accompanied by the suspension of previously held beliefs or openness to the as-yet-unknown. The generation of new knowledge through space exploration may be undermined by the way these forays into other worlds are accompanied instead by the replication and propagation of already-known habits from Earth.

So a second thought experiment poses the question, "What questions, assumptions and ideologies hitchhike with payloads journeying to the Moon?". The hitchhikers to be wary of are the ones who transport what they already know in order to make their discoveries more familiar. There may be something to glean about this tendency from the field of translation studies. Venturi (1998, p. 67), in a study that reveals the processes of literary mistranslation, writes: "Translation is often regarded with suspicion because it inevitably domesticates foreign texts, inscribing them with linguistic and cultural values that are intelligible to specific domestic constituencies". Venturi shows that cultural inflections can readily be deduced by comparing text translations made into dif-

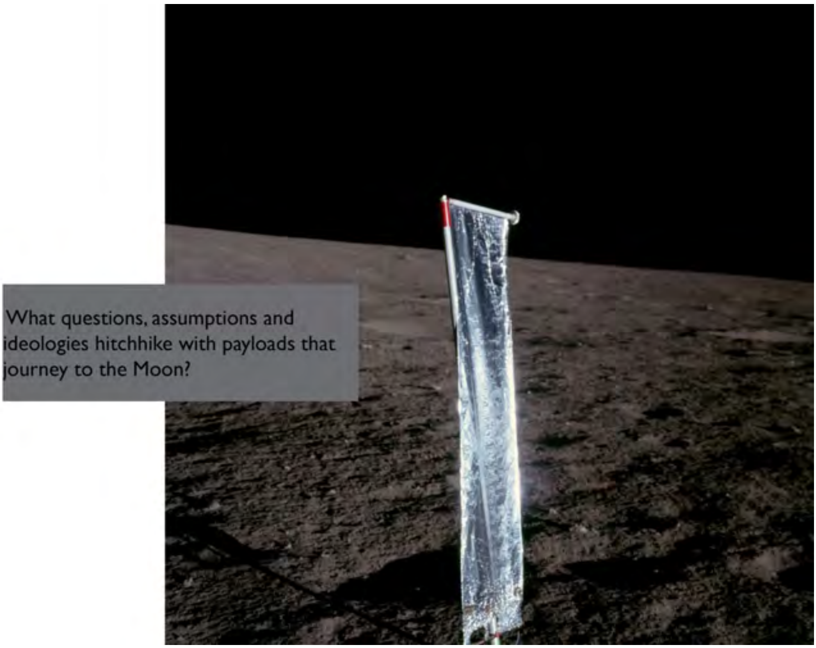

Fig. 2: Photograph from the Apollo 12 mission: "Solar wind experiment"

ferent languages and goes on to show that this process of distortion occurs in contexts other than language. Such domestication also takes place in other situations that involve encounters with, and interpretations of, the unfamiliar, and it could be that Moon missions follow this tendency when 'translating' the Moon for specific constituencies, most obviously for the scientific communities that design, operate and analyse the retrieved data. If this is so, scientific instrumentation, by virtue of the specificity of its data-gathering lenses, must inevitably be involved in mistranslations, both domesticating the foreign land and writing the observer into the observed. This may happen in ways that are particularly elusive because the processes of translation are neutralised, though not erased, by the filter of the scientific texts.[2]

Moon missions risk becoming a transport system whereby certain ideologies and habits of thinking from Earth are projected onto the Moon. There are two main problems to highlight here. One is that only certain ideologies make it onto the spacecraft.[3] The second problem is that projections from Earth, and the transported ideologies that accompany satellite missions to the Moon, construct what it is that the Moon is thought to be.

Transported ideologies

In terms of the first problem of which ideologies go into space, a comprehensive account of the way ideologies from American history are embedded in the rhetoric of spaceflight appears in the NASA History Division's compendium The Societal Impact of Spaceflight (2007). In an essay in this collection, 'Ideology, Advocacy and Spacefight', space policy researcher Linda Billings provides a chronology of examples showing how the concepts of 'progress' and 'frontier' have been transferred from American historical narratives into the future trajectory of the space industry, and how this has happened with little critique. In tracing the origins of frontier rhetoric to an essay in 1920 by Frederick Jackson Turner called The Significance of the Frontier in American History, she notes:

> In making the case for spaceflight, advocates continue to cite, directly or indirectly, Turner's frontier thesis and the related, potentially dangerous, idea of manifest destiny, seemingly oblivious to a changed cultural context and critiques of Turner's thinking (2007, p. 487).[4]

The names of the *Voyager* and *Pioneer* spacecrafts could be identified with such 'frontier' ideologies, stemming from episodes in American history, such as the voyage of the *Mayflower* and the pioneers who crossed the country in wagons. Another such ideology that has been hitchhiking to the Moon, and that can also be related to a key episode in American history, is that of mining. The Moon mission spacecrafts *Clementine*, launched in 1994, and *Lunar Prospector*, launched in 1998, reference the California Gold Rush of 1849 through the popular American folk song *Oh My Darling Clementine*.[5] These were not decorative titles either: both spacecraft had missions to "assess lunar resources".[6]

Tracing the courses by which such ideologies enter the framework of spaceflight is not always easy; there is little transparency through which to follow such moves, although connections can be intuited and the connected pursuits of science and specific, culturally derived utopias can be anecdotally discerned. As an example, the advocacy group The Moon Society,[7] publishes a monthly newsletter, 'The Moon Miner's Manifesto', which has the tagline 'Towards an Earth-Moon economy – developing off-planet resources'. The Moon Society promotes the idea of mining and of…

> … accelerating the day when there will be civilian settlements on the Moon, making use of local resources through private enterprise both to support the pioneers themselves and to help alleviate Earth's stubborn energy and

Fig. 3: Three of the convenors of the Global Lunar Conference Beijing 2010: Bernard Foing, Executive Director of the International Lunar Exploration Working Group (ILEWG) (left); Berndt Feuerbacher, President of the International Astronautical Federation (IAF) (centre); Phillipe Willekens, Executive Director of the International Astronautical Federation (right)

> environmental problems (The Moon Society, 2005).

This group advocates private enterprise as the ideological framework that should determine the future of the Moon. In this frame, the Moon becomes an object to be exploited for its resources. At the 2010 Global Lunar Conference in Beijing (which the author attended), this agenda seemed to have wide acceptance. Worryingly, the frameworks and criteria being used to determine the future of the Moon seemed to lack any critique; they build on a consensus that is reinforced by the organisation of the space industries – one that is not necessarily representative of a wider societal realm beyond these organisations, where the future of the Moon matters in other ways.[8]

This photograph of three key conveners of the Global Lunar Conference (Fig. 3) draws attention to the elusive question of how individuals closely associated with developing policy and technologies for the Moon might account for their own beliefs, ideologies and agendas.[9] This raises the question by what criteria, and according to which cultural systems, are the actions of space agencies held accountable, and what is the democratic process of technocracies in general?

A prevalent ideology attached to current Moon missions is that minerals found on the Moon are needed on Earth to solve the crises of energy and climate.[10] There are many problems with this way of thinking, not least that it sits uneasily with moves towards sustainable practices that promote better management of existing resources and move away from the environmentally destructive and often inhumane methods of mining. Such shifts towards sustainable practices expose the short-term behaviours adopted by consumer capitalism, rendering the pro-capitalist futures anticipated by the space industry out of synch with the more visionary paradigm shifts that are emerging in response to evidence of climate change. The ideologies that hitchhike into space can sometimes appear dislocated from current thinking, more atavistic than futuristic.

Reconstruction of the Moon

A second area to address concerns what the Moon is thought to be and how such ideas are constructed. If the Moon changes, or at least if the idea of what the Moon is changes, through the interventions of spacecraft missions, then the Moon can be said to be constructed in part through space technologies. These technologies are themselves socially constructed to some extent from within specific disciplinary constituencies that cannot be said to be either ideologically or culturally neutral, even if this may be the aspiration of scientific communities. Space technologies at some level translate, and at some level – even though it may be difficult to discern – create spaces and fissures through which the culture, ideologies and even the personalities of the investigating communities can intervene and travel to the Moon.
Here the insights of the cultural critic Edward Said provide a cautionary note. Said noted the effect such interventions by the observer had on the image Europeans constructed of South Asia. In Said's (2003 [1978]) seminal account, 'Orientalism' was the idea of the 'Orient' constructed from afar. What this suggests, much like Venturi's observations on translation studies, is the inability of those coming from one country to another to think afresh, to think from and with the land encountered, a land

Fig 4: Images from the Global Lunar Conference 2010, Beijing, China including a Technical Visit to the National Astronomical Observatories, Chinese Academy of Sciences, Beijing where a globe of the Moon was presented.

that preceded both their visit and themselves.[11] In Said's thesis, "the phenomenon of Orientalism ... deals principally, not with a correspondence between Orientalism and Orient, but with the internal consistency of Orientalism and its ideas about the Orient ... despite or beyond any correspondence, or lack thereof with a 'real' Orient" (2003, pp. 5-6). What Said notices is not just a discrepancy, but what has been invested in the idea of Orientalism, and the consequences of this. If the terms 'Orientalism' and 'Orient' are replaced with 'Moon missions' and 'Moon' respectively, a similar discussion around "the internal consistency of Moon missions and their ideas about the Moon" could draw attention to the fact that a version of Orientalism is present within recent scientific interventions. Such a move might insert the current investment in a particular construction of the Moon in its place as a temporal position or additional overlay in a history of versions of the Moon.

A collection of images taken during the Global Lunar Conference 2010 in China (Fig. 4) illustrates how the images of the Moon become mediated. The kinds of images currently being made of the Moon are very unlike the photographs taken by astronauts with Hasselblad cameras from the surface of the Moon (see Figs. 1 and 2). Furthermore, the way the images from the Moon are presented, in the particular context of a viewing room within a secure building, mean the terms on which the Moon can be encountered are identified with a specific, privileged audience. New artefacts continue to emerge out of this long-running translation process, such as the light-up globe illustrated, a potentially commercially popular product that is also a translation and a projection onto

Fig. 5: Exhibition model of Chandrayaan being transported in a pick-up truck in Bangalore in 2010

the assumed passivity and singularity of the Moon. At their core, such representations reconstruct the Moon as familiar and available to humans – or at least to certain humans. So the question returns of how to hitchhike to the Moon and intervene in the privileged logic of its construction. The next example of an actual experience of hitchhiking with the spacecraft *Chandrayaan* is introduced now as a means to further locate the kinds of transportations that occur, with and without intention, by way of spacecraft missions to the Moon.

Hitchhiking with Chandrayaan-1: the 'Moon Vehicle'

This hitchhiking experience happened by way of a two-year project, 'Moon Vehicle', based out of the Srishti art and design school in Bangalore. It was initiated in response to the mission of the *Chandrayaan-1* spacecraft, which was assembled in Bangalore and launched in 2008. Initially, the project aimed to draw out cultural associations of the Moon from the Indian perspective, of which there are many. The phases of the Moon are the reason for festivals, when particular foods are prepared and attention is paid to gods. Eating, farming and social activities have a correspondence with the Moon, more so in rural areas than in the cities. In the north of India there is a day when women fast for the well-being of their husbands. The fast ends when the Moon rises at which point the women are not to look directly at the Moon but only at its reflection in water or through the mesh of a sieve. The word '*Chandrayaan*' itself has an association with ancient mythology and can be translated as 'Moon Vehicle' but is more accurately a 'Moon Chariot'.

The most significant and unexpected value of the project, however, was as a vehicle for a transdisciplinary conversation. The Moon Vehicle project, which was urban in nature, taking place mainly in and around Bangalore, developed into a creative and critical enquiry into what it is that happens when a spacecraft goes to the Moon, asking what is changed on Earth and on the Moon as a consequence, and who is included in this journey and who is excluded? Members of the project began an amicable correspondence with the C1XS (pronounced 'kicks') team working on an x-ray instrument which was one of the payloads of *Chandrayaan*. By working in mutually beneficial ways, the C1XS team, art and design students from Srishti, and children living near the space agency base developed an ongoing dialogue. The project may look like what is often categorised by space agencies as 'outreach'; however, it was not intended as either outreach or public engagement, but to fulfill a different purpose: to act as a diagnostic from the margins of the space agency indicating that a shift

Fig 6: Making Moon analogues workshop MV2 Drishya Kallika Kendra, Bangalore, 2010

was needed, or an expansion in the thinking space, concept space, intentional space of satellite missions to the Moon.

The Moon Vehicle project used the mission of *Chandrayaan* as a proposition and a focus with which to find ways to visit the Moon without a spacecraft, to think through how these journeys might be imagined. The construction of 'Moon analogues' provided a way to build an imagination of the lunar world and a vocabulary of sorts with which to guide the experience of being on another planet.

One experiment involved no building, simply imagining a journey across a lunar landscape. It was a powerful experience – the mind has such unacknowledged capacities, which can be used to construct the totality of a visual environment in which it is possible to think experientially, reflectively and sympathetically within the Moonscape.

As these analogue experiments progressed, the project learnt that the Indian space agency was also embarking on the construction of an analogue site. The parallel experiments carried out within the Moon Vehicle project, though crude, provided sufficient vocabulary with which to share notes with the space agency scientists, and to know what kinds of questions to ask. The Moon Vehicle group (led by artists and children), however, felt it was able go one step further than the scientists: imaginative reconstruction is crucial for tests in the analogue environment and, in this, both artists and children can claim expertise. The distance between those making the space technology and those living nearby seemed to elide slightly onto a similar plane. But more than this, the encounter drew attention to the anomaly of confining the actual Moon experiments – an evidently expansive, multi-sensory and culturally delicate enquiry – to the scientific and technologically focused space industry.

The Moon Vehicle project, taking place outside the space agency but in correspondence with it, has some similarity with those external advocacy groups, such as the pro-mining Moon Society, that seek routes through which to reach the spacecraft and the construction of technology by building a parallel alternative imaginary. Curiously, although spacecraft are touched by very few, being located out of reach (both in terms of being physically at a distance and of being controlled from within confined organizations), the apparently passive recipients comprising the 'general public' can find mechanisms by which they can tactically include themselves – in much the same way as the resourceful hitchhiker when faced with limited funds and no vehicle.

The imagination of spacecraft

Another way to enrich the kinds of conversations that take place around space technology, and thus perhaps around space exploration activities, is to consider the nature of a technology such as a spacecraft as technological, biographical and ideological – an artefact consubstantially material and imaginary. In this endeavour, artists have a role in expanding the terms of reference, the space for criticality and the imagination of technologies.[12]

One of the most fascinating aspects of spacecraft is the ways in which they are inscribed with questions and aspirations, with traces of the biographies of their makers, with whom they are intimately entangled. Because of these entanglements, spacecraft inevitably emit something of the zeitgeist of the times in which they are built. This is one reason why there are calls for the care of the cultural heritage of space technologies.[13] This inscription happens despite, or perhaps precisely because of, the adherence to functionality and the limitations of technological capability in the making of space technologies. One of the effects of these unavoidable inscriptions is that spacecraft have ways to describe back to us historical and cultural moments, as splinters of ourselves. Some, such as myself (as an artist), go to great lengths to pursue the chance to get close to and learn from these interwoven complexities between people and things that are made more potent by their location in outer space.

It is clear that within the focus of the process of a mission to the Moon there is little time to grasp the implications or resonances that hover around the carefully described scientific goals and mission statements that it ostensibly adheres to. It is, though, of pressing importance to do this, because what happens away from the planet becomes amplified, subtly reinforcing and supporting similar kinds of practices on Earth, and incrementally devaluing others.

Concluding remarks

The purpose of this paper has not been to undermine the knowledge or achievements of the space industry, but to suggest a way of grasping an overview of what is being constructed by way of the Moon missions of spacecraft as a reminder that none of this is neutral or without complex and cautionary precedent. The mission-makers have a responsibility to attend to the consequences, but it is a responsibility that will always need to be shared.

My own attempts to expand and extend the conversation have felt both pioneering and isolating, welcomed by some individuals and institutions, but as equally resisted. The proposition of this paper is for small-scale satellite missions – these already have a natural advantage in that they are innovative – to foster the intellectual and creative critique of the certainties that have so far guided space exploration. These certainties have been useful; it has been useful to believe that exploration and science are manifestly justified, because it has allowed for so much to be achieved. Now, however, it is safe to remove these structural and structuring certainties, and to work with equanimity in a co-created space, capable of facing up to the unfamiliar, the untranslatable and the ineffable.

Epilogue

While I was giving my presentation, in an adjacent room, Buzz Aldrin, the astronaut who stepped onto the Moon with Neil Armstrong in 1969, was delivering a tribute to Armstrong, who had died only a few weeks earlier. I had wanted to be there, listening to the astronaut give witness, in some partial, inadequate but nonetheless poignant way, to his experience of being on the Moon.

After my presentation, I went over to the room where the tribute was still in progress. It was question time, and at the front of the room were some of the artists I had seen in the artists' symposium. One asked a question about music: had any of the astronauts experiences of music in space they would like to share? I knew from her presentation in the artists' symposium that she had previously been an artist-in-residence at the European Space Agency, and had developed instruments that had travelled to and been played on the Space Station. I wondered about the journey she had taken in order to put her proposal into action, to have her musical idea transported into space. I noticed how artists, without the funding of space agency employers, had found ways to attend the conference in Naples, in order to place certain questions within the framework of spaceflight, and the evanescent ways in which these questions, reminders and suggestions hitchhiked into the realms of outer space.

Notes

[1] International Astronautical Federation (IAF) (2012) Space Science and Technology for the Needs of All: *The 63rd International Astronautical Congress*. Mostra d'Oltremare Conference Centre, Naples, 1-5 October: IAF.

[2] For further discussions of the cultural implications of mistranslation, see Gayatri Spivak (1993). For a key discussion of translation between natural language and mathematics in scientific texts, see Sundar Sarukkai (2002). For a discussion of how instrumentation is not neutral but in many ways produces effects and data, privileging what can be measured above what cannot, see Hannah Drayson (2011).

[3] For further work about the ideologies that have accompanied spaceflight, see Walter McDougall (1985). See also Amitai Etzione's (1964) argument that there is nothing intrinsic to be gained by going into space other than ideological and political battles that would be more effectively worked out by other means.

[4] 'Manifest destiny' is the aggressively chauvinistic concept that implies the future territory of the United States will be the whole of North America. To understand the racialism directed at Canada and Mexico through this phrase, see the recent controversy over a GAP T-shirt emblazoned with this slogan. Available online at: http://www.guardian.co.uk/commentisfree/2012/oct/16/gap-manifest-destiny-t-shirt (accessed 23 January 2013).

[5] The lyrics are "In a cavern, in a canyon, excavating for a mine, dwelt a miner '49er and his daughter Clementine". The term '49er' refers to the 1849 Gold Rush.

[6] For both this reference and the Clementine reference, see author and curator David R. Williams, NSSDC, NASA (updated 2005). Available online at: nssdc.gsfc.nasa.gov/planetary/lunarprosp.html (accessed 21 January 2013).

[7] See The Moon Society's facebook page.

[8] The outcomes of the conference are recorded online. Available at: http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38863 (accessed 13 May 2013). Notably, these include the statement, "More possibilities for participatory engagement should be offered to the society for example via interdisciplinary activities with the humanities". This had not appeared previously.

[9] Bernard Foing, pictured to the left in the photograph, advocates robotic lunar villages over human exploration. At one point in the conference he asked for a show of hands of those who supported human and those who supported robotic exploration. The vote seemed to go in favour of robotic exploration, which Foing took to be indicative of a general consensus supporting his views.

[10] An example would be this quote, "Many of the precious metals and minerals we mine here on earth are also available in vast quantities on the moon without adverse impacts on our planetary environment" (The Star, 2013) from an online article Space, the final frontier for entrepreneurs: Everyone's getting in on the space action, even Justin Bieber published June 14 2013 by Ashante Infantry http://www.thestar.com/business/2013/06/14/space_the_final_frontier_for_entrepreneurs.html [Accessed 18 June 2013]

[11] See, for instance, Tejaswini Niranjana's (1992) Siting Translation, in which she analyses translations of poetry that include the replacement of references to Hinduism with references to Christianity.

[12] See Herbert Marcuse (1964: 2002, p. 71): "Naming the 'things that are absent' is breaking the spell of the things that are; moreover, it is the ingression of a different order of things into the established one – 'le commencement d'un monde'." See also Sundar Sarukkai's (2004, pp. 175-6) call for artists to redefine tech-

nologies: "I want to suggest here that artists can enlarge our understanding of technology, not by becoming technocrats but by enriching the ways in which we talk about technology."

[13] See Alice Gorman's papers (from 2005 to 2009) on the cultural heritage of space artefacts, and the compendium of essays by space engineers and archaeologists, *Handbook of Space Engineering, Archaeology, and Heritage* (2009), edited by Darrin and O'Leary.

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Appendix 4

Transcript (written by the author) of the film *Space and India* (1971) by director Vijay B. Chandra. As this is a rare film the transcript with thumbnail images is provided as a guide to the content referred to in the thesis.

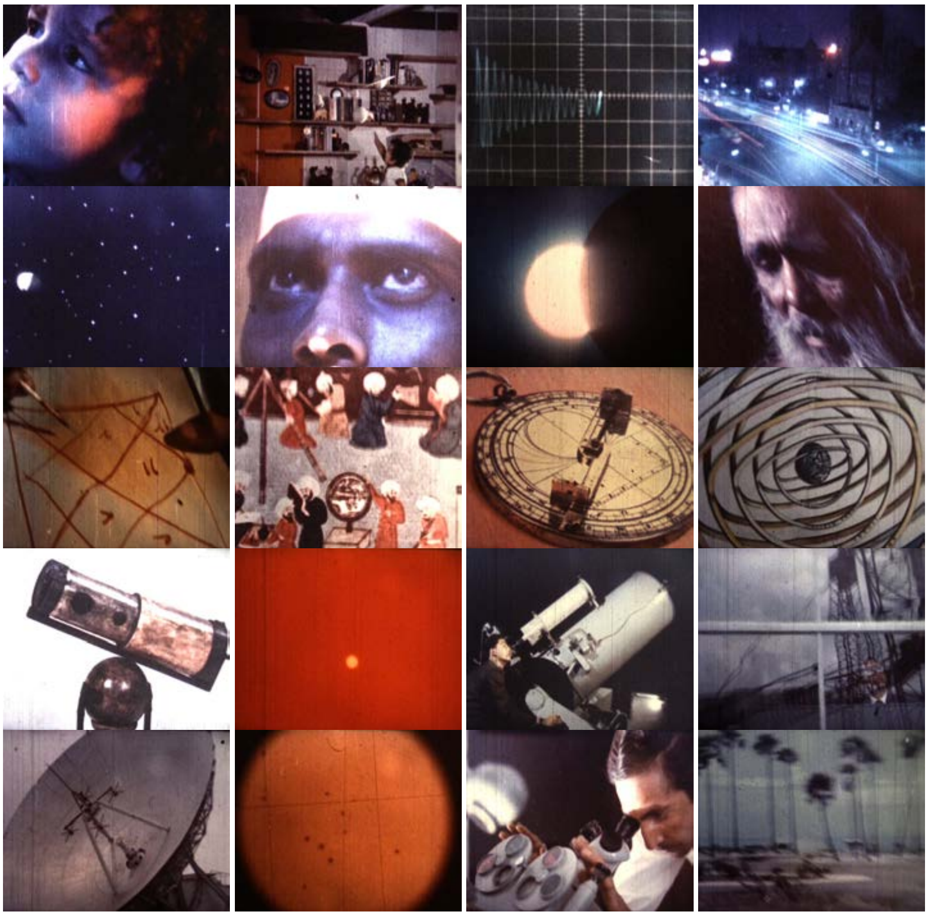
Citation: *Space and India.* (1971). [Film]. Directed by Vijay B. Chandra. Mumbai: Films Division.

Fims Division Homepage: http://filmsdivision.org/

Film transcript for *Space and India* (1971)
Directed by Vijay B. Chandra
Produced by Films Division India
Running time: 22 mins

Note: Voice over and spoken commentary are given in *italics*. The identity of the speaker is given where known. Words that are not clear are in [brackets]. Unknown words appear as [?] and phrases as [...?].

Opening sequence of a quick-cut edits (images below) with soundtrack of countdown, shrieking satellite signal sounds (the kind heard from the Sputnik satellite) overlaid with eerie, ambient 'sci-fi' music.



Space and India (Title)

Scientist 1: Organised space research activities in India started in 1962 with the commencement of the Indian National Committee of Space Research under the leadership of Professor Vikram A. Sarabhai.

Vikram Sarabhai: *It's not accidental that on the soil of India, the great space powers, United States, USSR and France are collaborating with us at the equatorial range near Thumba.*

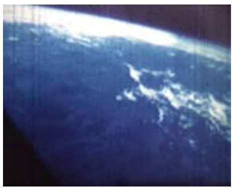
Scientist 2: The rocket launching facility at Thumba is [?]
It is the only rocket launching facility on the magnetic equator in the world.

Vikram Sarabhai: *In view of the United Nations sponsorship of this range, its not merely a matter of form, but constitutes an umbrella under which,*

regardless of individual [motives],

nations can collaborate in the peaceful uses of outer space.

Scientist 3: My interest has been on many aspects of Earth physics,



in particular the [problems] in the Earth's atmosphere ... Firstly the [?] in which weather phenomena take place.

Secondly, on the upper tiers of [atmosphere] which guides radio waves,

and thirdly on radiations from the sun that beam all energy to Earth.

Scientist 4: We have [two] major problems, one on atmosphere density, two on satellite radio beacons, three on [biometer payloads] and fourthly on space rockets.

Scientist 5: We are currently busy with the gathering of information about upper wind and temperatures over Thumba up to about 60 kilometres.

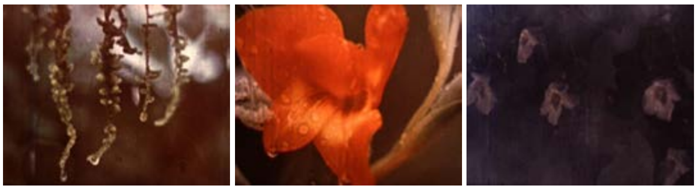
This information will be useful for supersonic aviation also.

Vikram Sarabhai: *It will be a constant endeavour, in the years to come, to provide the peaceful uses of outer space for the real problems of this nation.*

Image sequence beginning with planet animation, then sunset, then plant life. Atmospheric soundtrack of Theremin and abstract sounds.

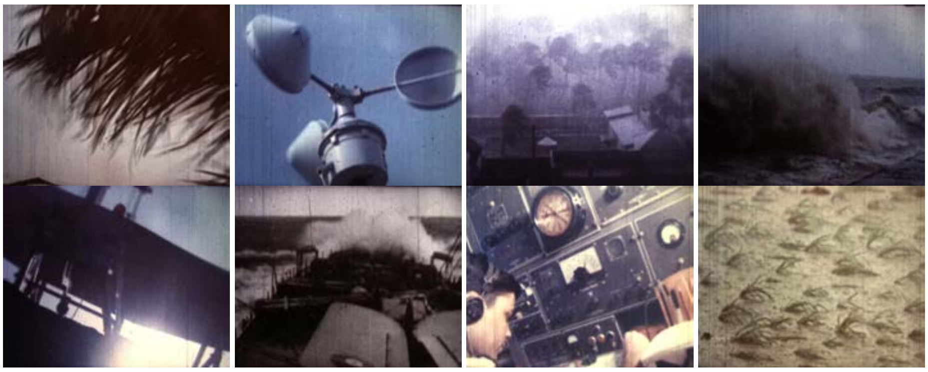
Scientist 3: What a wonderful thing the Earth's atmosphere is,

[?], protective, living and life-giving.



[...?] However weather has its moods.

Noisy storm sequence. of wind blowing through coconut trees, waves, ship at sea and communications radio operator.



Can we predict them?
Scientist believes in the laws of physics and is confident that he can.

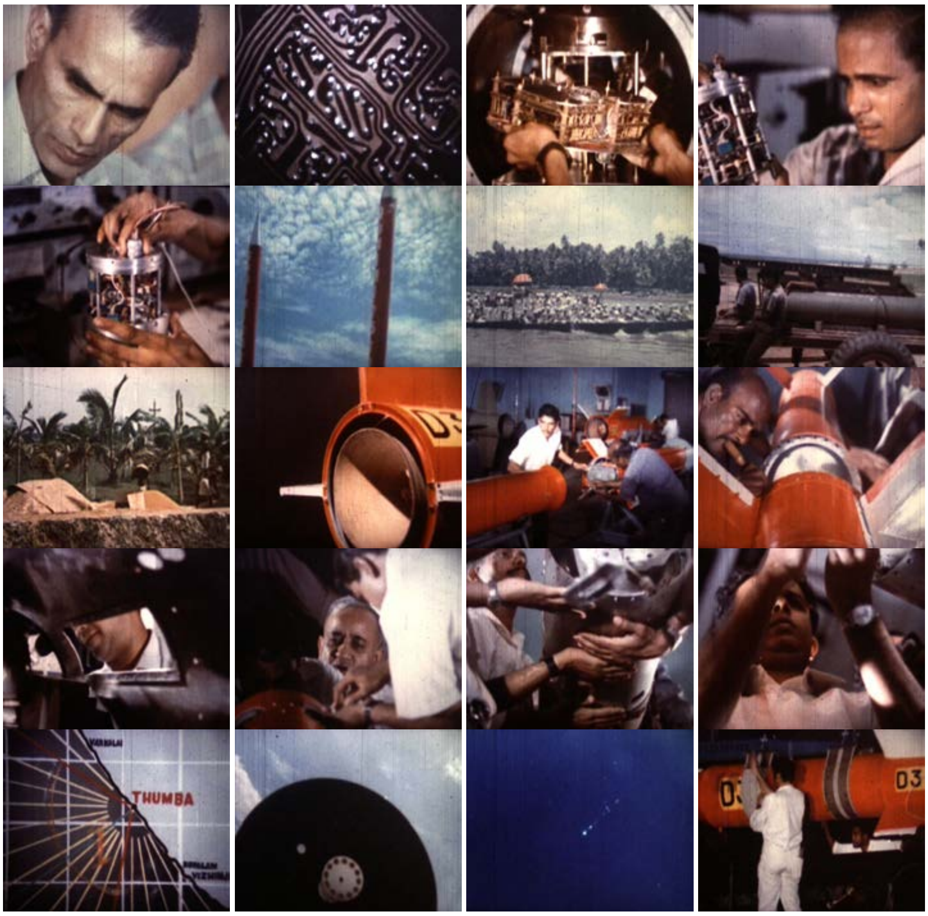
Many scientists have till recently depended on observations made at land and sea stations and on upper wind and temperatures determined from balloon observations.

Received data both directly and by broadcasts both national and regional. The data is collected at national meteorological centres, like Delhi or Pune in our country and broadcasts are issued for aviation, shipping, farmers and others.

We have now begun to get extended global [?] pictures taken from orbiting satellites. They cover the whole of India, the whole of the of the southern and northern hemispheres [...?] And this is new additional information that is now forthcoming due to the satellites.

Scientist 1: The main activities confined to conducting scientific research with the help of balloons and rockets and receiving real-time [?] data from the scientific satellite for the [?] of weather [?] ionosphere and astronomy.

Long image sequence mostly concerned with construction of rockets and delicate assembly of instruments. Soundtrack is pounding drums and Theremin alternately.



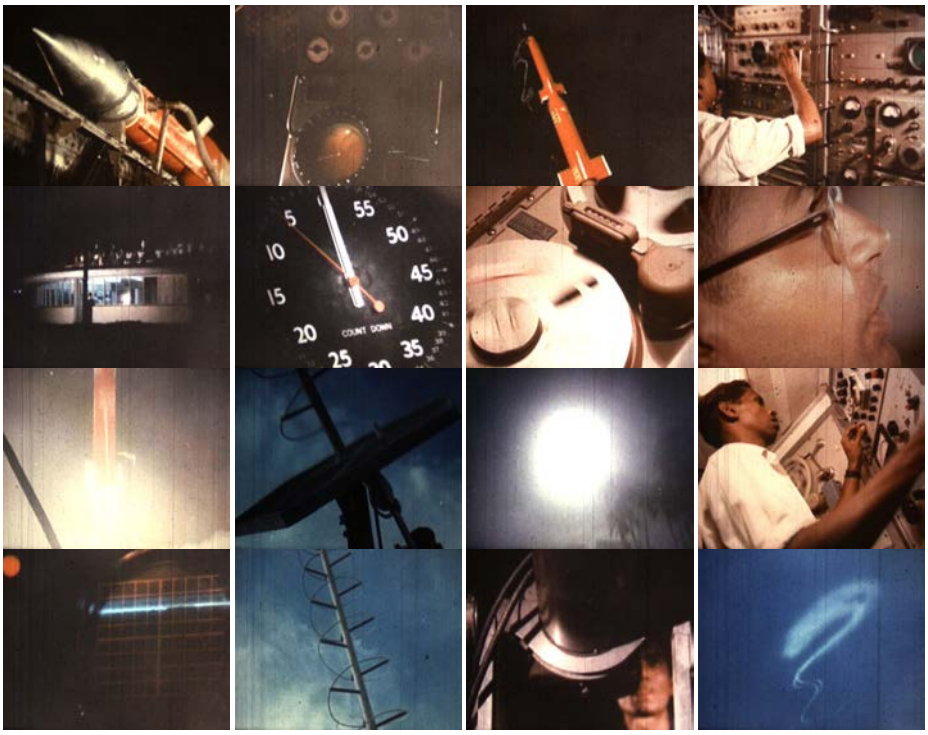
Off camera voice: Tell me why Thumba is so important?
Scientist 2: It is the only station along the magnetic equator from where the scientific phenomena [?] can be studied in detail.

In collaboration with five different countries - United States of America and USSR , France, Japan [?] scientists come here for experimenting and collaboration. Quite a number of rockets were launched with scientific payloads and most of them were successful.

Many educated scientists and engineers who can usefully employ, and they can contribute a lot to establish independent technology and know-how.

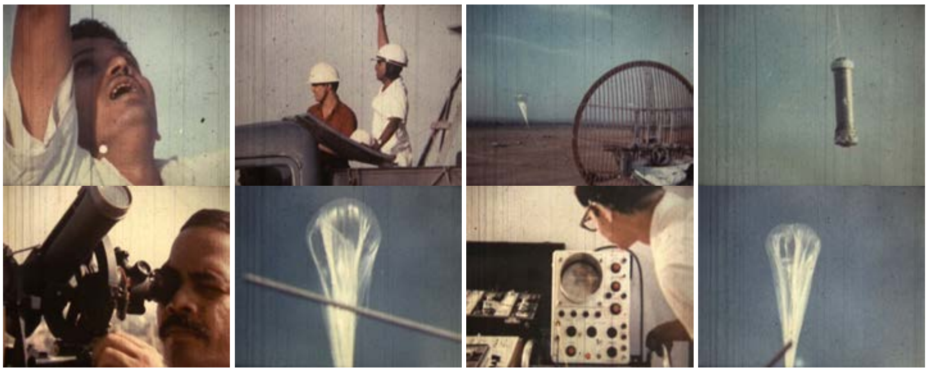
This will be useful in the field of electronics, instrumentation and [?] systems and [?] technology {?] will be of great value for our country and it will give spin off because many industries contribute quite a lot to the development of this technology.

Count down and launch soundtrack *10, 9, 8, 7, 6, 5,4,3,2,1, zero*...



(High altitude balloon launch)

Voice: [control ...?] We are ready to launch... Balloon go!

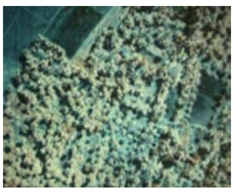


Scientist 5: Balloons carrying instruments to the high altitude for the study of cosmic ray and x-ray astronomy. The information obtained is very important and will help in solving the riddle of origin of the universe. The knowledge of ultimate [?] the man has been curious for ages. The national facility at Hyderabad will undertake [?] experiments has been established by the group of scientists interested in cosmic ray research at the Tata Institute of Fundamental Research, Bombay and is available to the scientific community at research institutions and universities in the country and abroad.

(Remote sensing.)

Specially instrumented aircraft and satellites are being sent up for the mission of the earth [?]

This data are sent back to the earth in the form of photographs.



This technique is known as remote sensing. This is nowadays being applied for detecting the plant diseases in good time.

These pictures of coconut trees taken from [?] are to be related to the information of the individual coconut trees at the Thumba station, [?] and [Kayamkulam?]. Studying the case histories of species and deducing [...?].

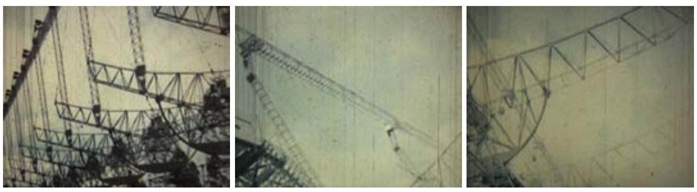
(Ooty Radio Telescope.)

Interviewer (Chandra?): Dr Swarup, what aspects of astronomy are you particularly interested in here?

Govind Swarup*: We have set up a radio telescope for studying radio waves that come from distant stars and galaxies in our universe, using Moon as a tool.*

As the Moon moves in the sky, the distant radio source is occluded by the sharp edge and thus its position is determined very accurately.

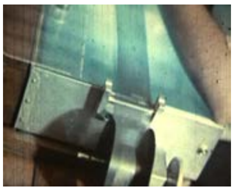
This is a very powerful method that has not been exploited so far because of the lack of a suitable instrument. The radio telescope that we have set up is one of the largest of its kind in the world.



Interviewer: Professor [?] what do you mean by the optical tracking satellites?
Professor: In optical tracking one tries to photograph the satellite against the background of the stars, which serve as a frame,

and to time this accurately so that computation of [?] orbit of the satellite will be possible.



Such studies have, in the past ten years or so, given us much information about atmospheric air densities at a height of 1000 km or so.

They have also helped in the [?] determination of the shape of the Earth and the [?].

The position of the [?] observatory for instance is now known to an accuracy of 10 metres.

Interviewer: Position you mean on the Earth?

Professor: Yes, sure on the Earth.

(Kodaikanal Sun observatory)

This is one of the top solar observatories in the world.

We have got an active group who are working on the solar prominences, on the solar [?] flares, on the photospheric [?] and so on.

We are inside this horizontal solar telescope and from these solar lines we can tell many things of the conditions of the solar atmosphere.

(Communications.)

Scientist 6: Space research has given a new dimension to modern communications, in particular to television. With an annual investment of 30 crores one can provide services to all the 560.000 villages in India over a 5 yr period.

Vikram Sarabhai: *Let's look at communications... The single satellite will be over the equator, somewhere around here perhaps, and the fact that from an altitude 45 000 km it can be seen by a very large area that we are going to focus the beam. Will permit us to have a high signal strength for all these stations.*

The biggest breakthrough that is likely to take place is a great economy is the cost of the ground station that you can take it to. A normal Earth ground station such as [RV?] costs several crores of rupees, but, with an increase of power on the satellite it will be possible, to directly receive to television sets with small antennas, and this whole installation might cost no more than 2000 rupees.

So notice the tremendous difference between several crores and 2000 rupees and this is the advanced technology that has been possible.

Not only television, but for point-to-point communication between our major metropolitan areas. It should be possible through a national satellite to have 2600 high quality telephone channels as we are now planning in 1975. And it should make possible direct dialling from your telephones to anywhere in India at a minimum cost.

The Experimental Satellite Communication Earth Station at Ahmedabad which we have set up through the generous assistance of the United Nations development fund and the International Telecommunications Union, is a unique example of an institution to provide advanced training and research facilities in the field of satellite communications.

Vikram Sarabhai*: In my opinion the aspect of space research which I would like to stress most is in relation to the national capability, the self-confidence that this will generate and if I were to give my own evaluation of this, I think the benefits of this far outweigh all the rest that we have been talking about.*

Final image sequence with fast cuts between scientists and instruments. The scientists' mouths move but their voices are removed and the soundtrack is fast-paced.

(Credits)

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Words and voices — participating scientists

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